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WAR MACHINE

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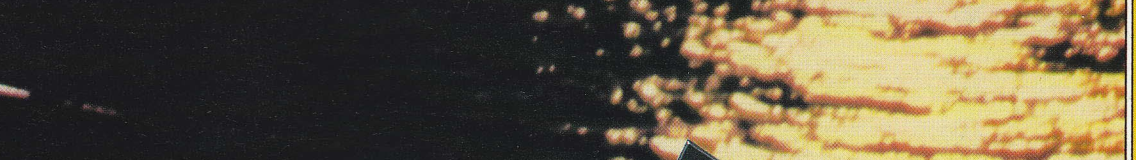
Close-in Weapon Systems

SAMs in Action in the Falklands

US SAM Development

Launch Systems



A fully illustrated guide to Naval Surface-to-Air Missiles

WAR MACHINE

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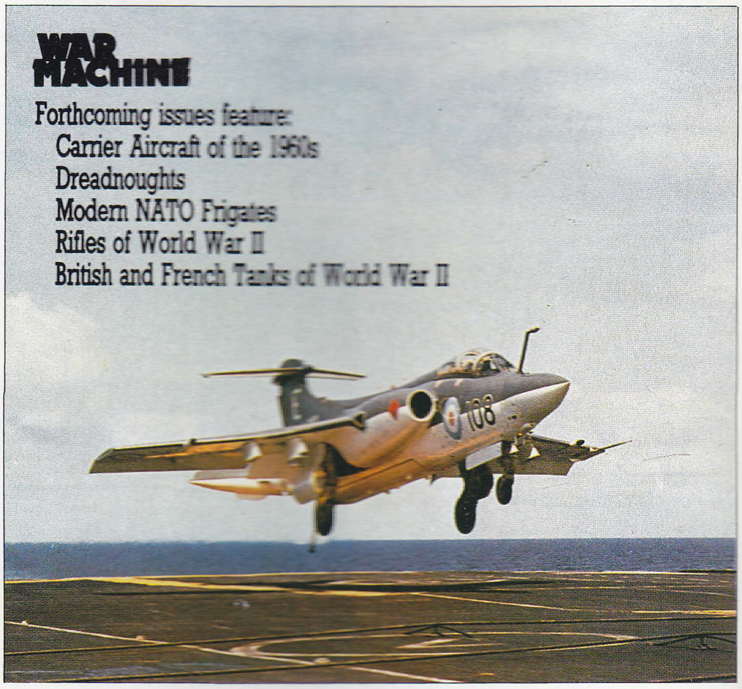

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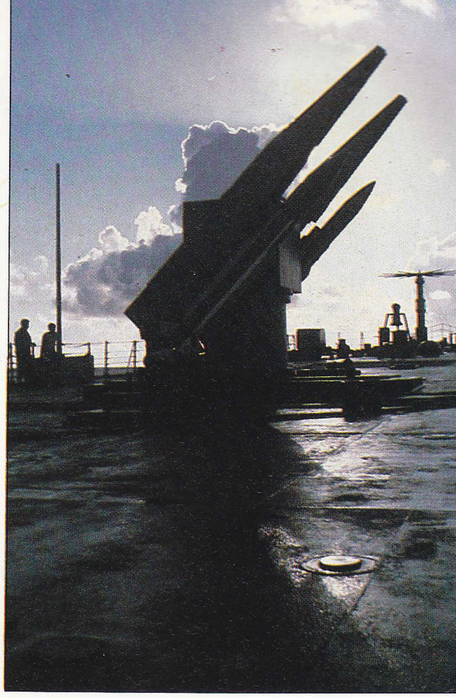
Naval Surface-to-Air Missiles

Nowhere has the technological revolution affected warfare more than at sea. Today's warships fight with radar, computers and missiles to the extent that where fighting ships formerly bristled with light and heavy anti-aircraft guns, modern defences consist of a few solitary missile launchers.



Silhouetted by the dawn, the twin Mk 26 launcher of the nuclear-powered cruiser USS Mississippi *is loaded with two Standard SM-1 MR missiles.*

During the period after World War II a vast array of research establishments, special trials ships, apparently unlimited money and groups of industrial contractors were employed to solve the problem of furnishing major surface combatants with a surface-to-air missile (SAM) defence that was able to go to sea.

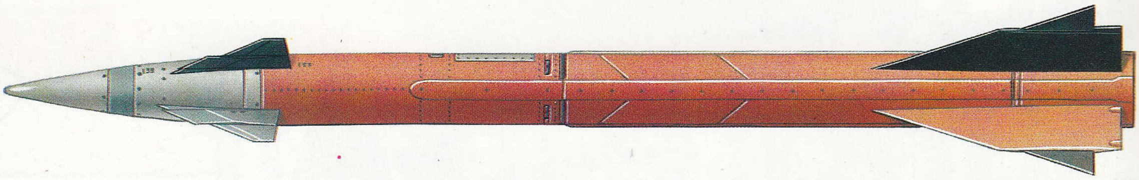
Although the launcher and its missile were from an early stage seen to be the answer, it required considerable resources just for the peripheral equipment and redesigning of the ships to carry the systems. For example, most of the first-generation missiles literally had to have the launch vessels stripped to the framework and rebuilt just to accommodate the associated magazines, power supplies and electronic systems below decks; then provision had to be made for the launchers and radar equipment above decks. By the early 1960s these beam-riding area-defence missiles were overtaken by a second type specifically designed for short/medium-range defence of individual vessels, such systems being typified by the Tartar and Sea Cat systems. Surprisingly, in all the 'brush wars' fought around the world it was not until the Vietnam War that the naval SAM was first fired in anger. This war allowed the area-defence weapon (in the form of the Talos and Terrier) to be fired on a number of occasions against North Vietnamese MiG aircraft, scoring a total of seven known kills. The short-range systems did not get their chance until the 1982 Falklands war, when dozens of Sea Dart, Sea Slug, Sea Wolf and Sea Cat missiles (as well as land-based Blowpipe and Rapier SAMs) were fired as part of a layered air defence network against Argentine aircraft. Although recent evidence suggests that the naval SAMs downed a combined total of only 11 aircraft, this weapon proved itself once and for all to be more efficient than the gun in anti-air warfare defence.

A British Aerospace Sea Dart missile is launched. Sea Dart, an area defence system, was used operationally for the first time in the 1982 South Atlantic conflict, shooting down at least five aircraft.

FRANCE

Naval Crotale

Derived from the ground-launched Crotale system, the **Naval Crotale** variant was designed as a self-defence missile for use by ships against medium-altitude, low-altitude and sea-skimming attacks by aircraft, helicopters and missiles. It can also be used against surface targets in an emergency. The standard **Naval Crotale 8S** version comprises a turret assembly with two co-axial units (one with eight ready-to-fire missiles in their container-launchers and the other supporting the fire-control radar and IR tracking systems), a shelter housing the electronic data-processing cabinets, and an operator's console in the combat operation centre for supervising the system and sending the fire orders. A new version, the **Modular Naval Crotale**, is now available with either an eight-missile **Modular Naval Crotale (8MS)** or a four-missile **Modular Naval Crotale (4MS)** launcher turret for installation on ships down to 500 tons displacement. In all cases the target acquisition and tracking is performed by the radar of the Naval Crotale system itself after it has been designated by the ship's sensors. Missile guidance is performed by an improved line-of-sight unit. For sea-skimming targets both the missile and target are tracked by a differential IR technique. Once in the vicinity of the target the warhead is detonated by an infra-red proximity fuse with a built-in time delay so that the prefragmented splinters formed by the detonation are concentrated to impact in the most vulnerable zone of the target. A total of 18 reload rounds is normally carried for the eight-round launchers. In the French navy the basic Naval Crotale 8S version is fitted to the 'Georges Leygues' and 'Tourville' classes, whilst the Saudi Arabian Navy has bought the Modular Naval Crotale 8MS system for the two frigates being constructed in France.



Naval Crotale uses the same basic solid-fuelled Matra missile as the land-based version, having a Mach 2.5 performance and capable of tackling anti-ship missiles.

GES LEYGUES
D640

The destroyer Georges Leygues *is seen tied up alongside the wharf in Beirut. The eight-round Crotale launcher and its associated radar systems are prominent at the top of the photograph.*

Specification

Naval Crotale
Type: point-defence missile
Dimensions: length 2.89 m (9 ft 5.8 in); diameter 0.15 m (5.9 in); span 0.53 m (1 ft 8.7 in)
Weights: total round 85 kg (187 lb); warhead 15-kg (33-lb) HE-fragmentation
Performance: maximum speed Mach 2.3; range 0.7-13 km (0.43-8.08 miles) against helicopters and non-manoeuvring targets, or 0.7-8.5 km (0.43-5.28 miles) against manoeuvring targets, or 0.7-6.5 km (0.43-4.04 miles) against sea-skimming targets; altitude limits 4-5000 m (13-16,405 ft)

FRANCE

Masurca

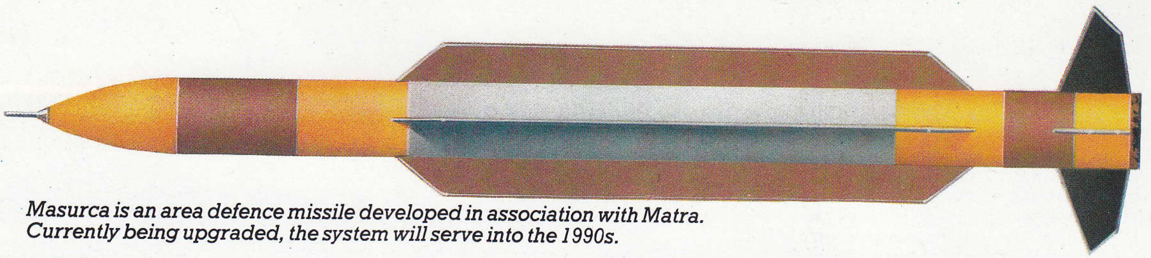
Developed in the mid-1950s, the **Masurca** is a wholly French-designed and French-built medium-range solid-propellant area-defence naval SAM for task force and carrier escorts. Only three French ships are equipped with the missile and its associated radar systems, namely the missile frigates *Duquesne* and *Suffren* and the cruiser *Colbert*. Each vessel has a 3D surveillance radar, a weapon-direction system, two independent fire-control radars and a twin-rail launcher with a 48-round magazine. Two types of guidance were developed for the definitive production version, the **Masurca Mk 2 Mod 2**, which used a command to line-of-sight beam-riding technique and for the **Masurca Mk 2 Mod 3** which introduced a semi-active radar seeker into service. Only the latter system remains in service, the former having been phased out in 1975. A solid-propellant booster unit is fitted, and in under 5 seconds this accelerates the missile to a speed of about Mach 3, at which point the sustainer motor takes over. During flight the missile follows a trajectory which is determined by proportional navigation as it keeps its antenna pointed at the target illuminated by one of the two fire-control radars. The Masurca system is currently undergoing an upgrading programme to increase its reliability and to improve its engagement envelope so that it can be used well into the 1990s.

Specification

Masurca Mk 2 Mod 3
Type: medium-range area-defence missile
Dimensions: length of missile 5.38 m (17 ft 7.8 in) and of booster 3.32 m (10 ft 10.7 in); diameter of missile 0.406 m

Originally a relatively primitive beam-riding command guidance missile, the Masurca is now, as the result of continuous development, a sophisticated SARH (semi-active radar homing) missile with a range of 50 km (31 miles).

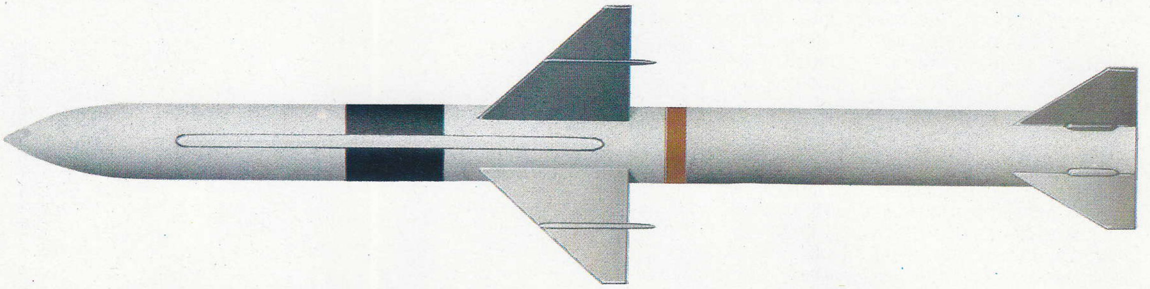
(1 ft 3.98 in) and of booster 0.57 m (1 ft 10.44 in); span of missile 0.77 m (2 ft 6.31 in) and of booster 1.50 m (4 ft 11.05 in)
Weights: missile 950 kg (2,094 lb); booster 1148 kg (2,531 lb); warhead 100-kg (220-lb) HE-fragmentation
Performance: maximum speed Mach 3; range 50 km (31 miles); altitude limits 30-23000 m (100-75,460 ft)



Masurca is an area defence missile developed in association with Matra. Currently being upgraded, the system will serve into the 1990s.

ITALY

Albatros



Above: Albatros has been developed by Selenia using Aspide missiles, which also serve as air-to-air weapons amongst other roles.

The **Albatros Mk 2** medium-range surface-to-air missile system uses the Aspide multi-role missile and can be integrated with various types of shipboard fire-control systems. It can engage anti-ship missiles of either the pop-up or diving type as well as the normal range of manoeuvring aircraft targets. The original **Albatros Mk 1** system developed in 1968-71 utilized the RIM-7H5 missile of the NATO Sea Sparrow project. Like the Sea Sparrow, the Aspide missile uses semi-active radar homing, the trajectory to the target being of the collision type with proportional navigation. Target-illumination is by a continuous-wave radar array which is part of the ship's electronic outfit. The launcher can either be a standard eight-round cell with associated reload magazine, or for ships down to 200 tons a four-round cell which can be reloaded if required via standard shipboard replenishment at sea facilities. Each missile is stored in its own canister that also serves as the launch tube. The missile is basically the same as the air-launched version but has cropped wings and fins. Since it was developed, the Albatros missile system has been adopted by 15 countries throughout the world (Argentina, Ecuador, Greece, Iraq, Italy, Japan, Libya, Nigeria, Peru, Spain, Venezuela and four others).

Specification
Aspide
Type: point-defence missile
Dimensions: length 3.70 m (12 ft 1.7 in); diameter 0.203 m (8 in); span 0.80 m (2 ft 7.5 in) **Weights:** total round 204 kg (450 lb); warhead 33-kg (72.75-lb) HE-fragmentation
Performance: maximum speed Mach 2.5+; range 18.5 km (11.5 miles); altitude limits 15-5000 m (50-16,405 ft)

CON LEALTAD Y CORAJE

Right: An Aspide missile is launched from the Albatros system of a 'Lupo' class frigate built in Italy for the Peruvian navy. Albatros has been adopted by 15 navies to date, including that of Italy.

Below: An Aspide missile is launched from the octuple launcher of an Italian 'Maestrale' class frigate. The Albatros system is replacing the NATO Sea Sparrow system in the vessels of the Italian navy.

Close-in Weapon Systems

The biggest threat in modern naval warfare comes from the high-speed, sea-skimming missile, and much effort has been made to find an effective last-ditch counter. In most cases, the solution has been a gun system with a high rate of fire.

Fleet air defence is based on the attrition of attacking aircraft and missiles by defence in depth, initially by combat air patrols (working in conjunction with airborne early warning aircraft) along the axes of highest threat and then by 360° coverage with missile systems of progressively shorter range. However, with the advent of modern cruise missiles that have sea-skimming and underwater-launch capabilities, there was need for new lightweight defence systems to work effectively as 'last-ditch' weapons in the engagement of attackers leaking through the outer defence zones or popping up from cruise missile submarines at relatively short range. These weapons were required to destroy the incoming missiles far enough out to prevent them from maintaining a ballistic trajectory and crashing into the defending ship. The systems were also required to have a very high individual-round kill probability, an extremely fast reaction time, a high rate of fire and an extremely good first-time hit capability.

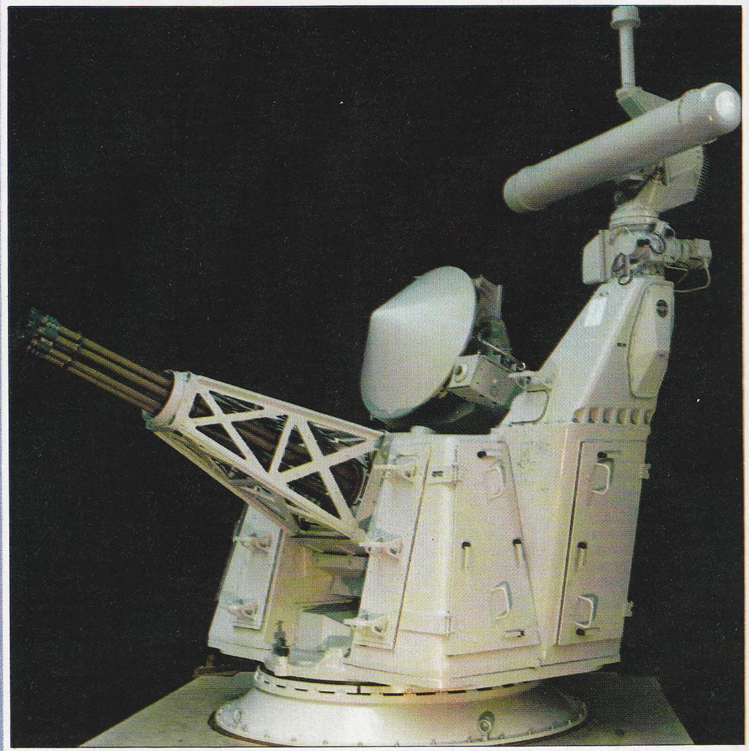
To meet this the US Navy designed and built the 20-mm Phalanx close-in weapon system (CIWS) with a six-barrel M61A1 'Gatling' gun and a very effective depleted uranium projectile. The Royal Navy decided upon the Sea Wolf automatic missile system to follow on from the previous Sea Cat missile. Unfortunately the Falklands war showed a need for both types of system (especially against sea-skimming missiles), so the Royal Navy has adopted the Phalanx as an interim CIWS for her carriers and the Dutch 30-mm Goalkeeper CIWS for certain new-build ships. Existing ships' close-range defences are being upgraded by the installation of more basic gun systems and the carriage of the new Javelin portable air-defence missile.

The US Navy is planning to supplement the Phalanx on certain ships with the Rolling Airframe Missile that uses passive radar homing and IR guidance against active radar-homing cruise missiles.

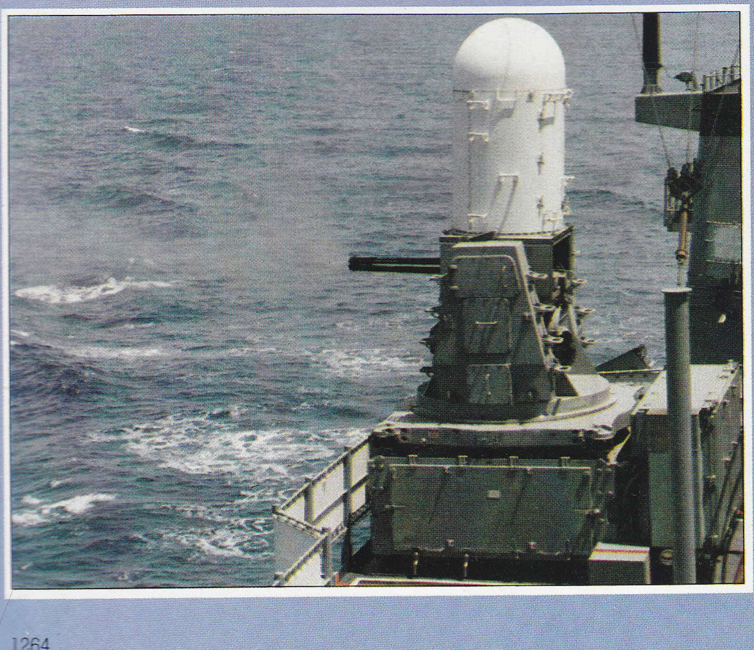
The Soviet navy, as the chief operator of the anti-ship cruise missile, had in the meantime analysed the defence against such weapons correctly, and had thus gone for a missile/gun mix from the start. The SA-N-4 'Gecko' was used as the outer layer of the defence network, with rapid-fire 76-mm (3-in) and 100-mm (3.9-in) guns as back-up before the missiles could reach the final close-range area covered by the 30-mm ADG6-30 'Gatling' gun mount. Most Soviet surface ships were equipped with combinations of these systems from the early 1970s onwards. The Soviets are now actively engaged in bringing a second-generation network into service, this being based on a vertical-launch point-defence missile with capability against cruise missiles, the SA-N-8, and upgraded versions of the ADG6-30, possibly with depleted uranium ammunition or an equivalent.

Other European nations have gone for a less sophisticated mix of guns and missiles. Italy designed and has exported the 76-mm (3-in) OTO-Melara Compact gun and the 40-mm Dardo close-range defence system, together with the Albatros lightweight short/medium-range missile system. Although considerably less expensive than the systems of the larger naval powers, the capabilities of these systems appear to be of the same order, although they have yet to be combat tested. One country that has considerable experience of naval missile warfare, Israel, has gone its own way and is fitting Barak point-defence missiles and either a locally designed 30-mm gun system or a Phalanx mount to Israeli vessels.

For the future there are already rumours of a Soviet laser anti-missile defence system for major capital ships, to be fielded in the late 1980s. So far the US Navy has remained quiet about this, although it is probably not far behind with such a system.



Goalkeeper is a Dutch-designed system with a 30-mm Gatling type cannon manufactured by General Electric in the USA, with electronics by Hollandse Signaalapparaten. The system has been chosen by the Royal Navy for new-build vessels.



Left: The General Dynamics Phalanx system makes use of the 20-mm Vulcan cannon developed for aircraft use in the 1950s. Primary CIWS for the US Navy, the Phalanx has been fitted to the Royal Navy's 'Invincible' class carriers.

Above: The ADF6-30 30-mm cannon is in widespread use throughout the Soviet navy, ranging from the eight mounted on Kirov and Kiev (two of which are seen above) to the single units fitted to 'Nanuchka' class corvettes and smaller vessels.

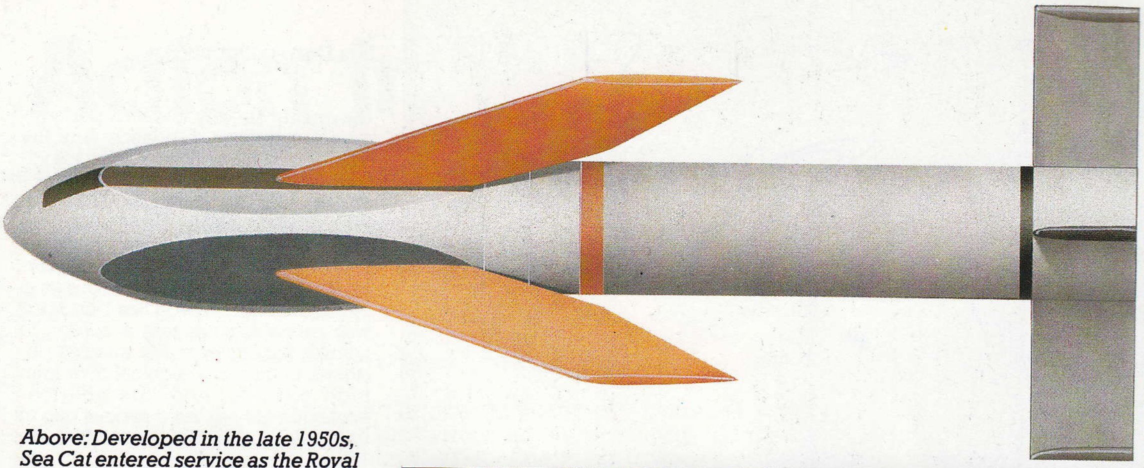
UK

Sea Cat

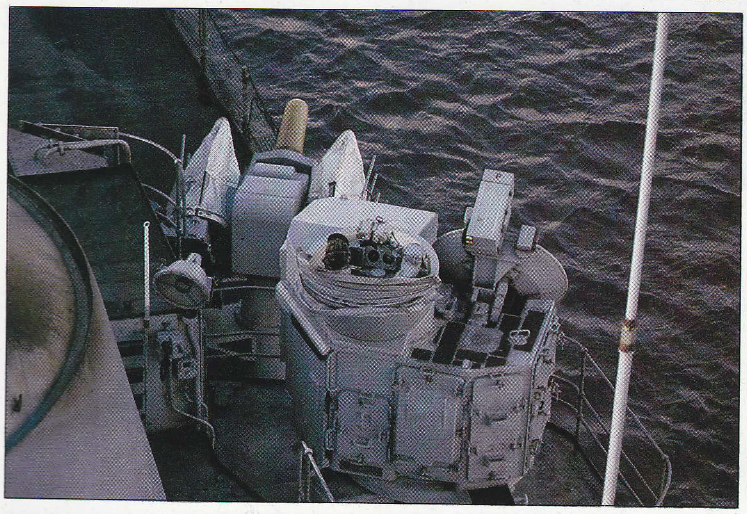
Designed and built by Short Brothers in the late 1950s, the **Sea Cat** was the first shipborne SAM system designed for close-range air defence in place of rapid-firing guns such as the 40-mm Bofors. The first guided trials took place in 1960, the initial shipboard trials following on board HMS *Decoy* in 1961. A series of full-scale shipboard trials before service acceptance was then undertaken in 1962 aboard the same ship, the missile system becoming known as the **Guided Weapon System (GWS) Mk 20** in the Royal Navy. The Sea Cat has a dual-thrust motor, four fixed fins, hydraulically-driven wings and a continuous-rod blast warhead with both delayed action contact and proximity fuses. The missile is guided by radio command and can be integrated with almost any type of sighting and fire-control system, as the continual improvement and updating programme in the Royal Navy has proved with the introduction into service of the **GWS Mk 21** and **GWS Mk 22** versions with different radars to give darkfire capabilities. The system is due to continue in service with the Royal Navy until the mid-1990s. The launcher used most often is a quadruple hand-loaded version, although some of the countries to which the missile has been exported use a lightweight triple unit. Since it entered production in the 1960s 16 navies have bought the missile, but it was not until the 1982 Falklands war that it was used in combat. There it proved to be a useful 'scare' defence, but its use against modern high-performance manoeuvring targets must now be somewhat in doubt. Operator countries are Argentina, Australia, Brazil, Chile, India, Iran, Libya, Malaysia, the Netherlands, New Zealand, Nigeria, Sweden, Thailand, UK, Venezuela and West Germany.

Specification

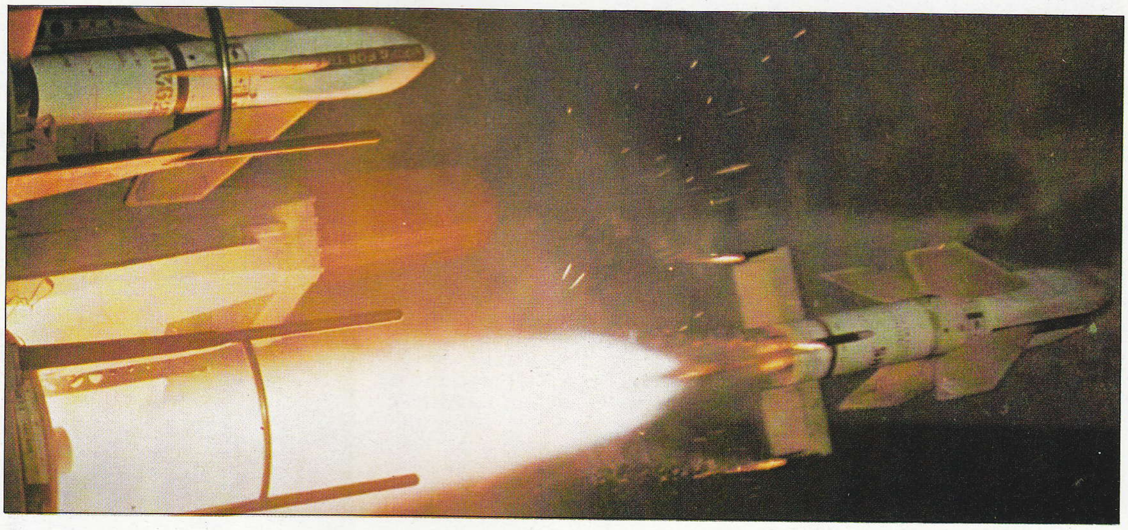
Sea Cat
Type: point-defence missile
Dimensions: length 1.48 m (4 ft 10.3 in); diameter 0.1905 m (7.5 in); span 0.65 m (2 ft 1.6 in)
Weights: total round 68 kg (149.9 lb); warhead about 10-kg (22-lb) HE-fragmentation
Performance: maximum speed Mach 1; range 5.5 km (3.4 miles); altitude limits 30-915 m (100-3,000 ft)



***Above:* Developed in the late 1950s, Sea Cat entered service as the Royal Navy's primary short-range air defence system in the early 1960s, replacing gun systems such as the 40-mm Bofors.**



***Right:* Seen aboard the 'County' class missile destroyer HMS Antrim in the South Atlantic, Sea Cat first saw action in the battles around the Falkland Islands. While rapidly becoming less than effective against high speed targets, several Argentine aircraft were believed to have been destroyed by the system.**

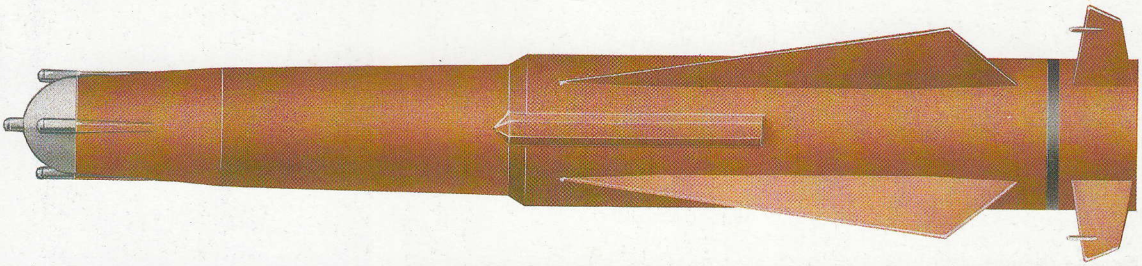


***Below:* Launched from the standard four-round launcher, Sea Cat is effective to about 5.5 km (3.4 miles) and is capable of Mach 1. Interceptions can be made between 10 and 915 m (30-3000 ft). Sea Cat is in service with some 15 navies, including that of Argentina.**

UK

Sea Dart

The **Sea Dart** (or **Guided Weapon System Mk 30** to give it its Royal Navy title) was designed by British Aerospace in the 1960s as a third-generation area-defence naval SAM capable of engaging targets such as aircraft and missiles at both very high and, under certain circumstances, very low altitudes. The system was used operationally during the 1982 Falklands war, being officially credited with eight kills. However, recent evidence suggests that the number was actually five: an Aérospatiale Puma helicopter, a Learjet 35A reconnaissance aircraft, a BAe Canberra B.Mk 62 light bomber and two McDonnell Douglas A-4C Skyhawk light attack aircraft. The last aircraft was shot down outside the missile's official engagement envelope at very low level. The launcher is a twin-rail unit and is coupled with two Type 909 target tracking and illuminator radars on the Type 42 (20 missiles) destroyers, 'Invincible' class aircraft carriers (20 missiles), and HMS *Bristol* (40 missiles), the sole Type 82 class destroyer built. Sea Dart can also be used out to 25-30 km (15.5-18.6 miles) against surface targets if required. The system was also sold to Argentina for its two Type 42 destroyers, and this probably explains the relative lack of kills by the system during the war as



Sea Dart is an area defence missile, powered by a Rolls-Royce Odin ramjet with rocket booster for launch. The missile depicted has a cover over the ramjet intake.

Sea Dart (continued)

the enemy already knew its performance capabilities. Guidance is of the semi-active homing type with associated proportional navigation. A ramjet engine powers the missile in flight after a solid-propellant booster unit has brought it up to the velocity required for the main engine to take over. Unfortunately, in the 1981 defence cuts a considerably improved **Sea Dart Mk 2** was cancelled: this was a version to combat the Soviet cruise missiles designed to go into a terminal dive from high altitude, and this politico-economic cut has left a serious gap in fleet defences for the period of the late 1980s and early 1990s. A **Lightweight Sea Dart** system has also been developed for ships down to 300 tons displacement: this uses deck-mounted container-launchers with simplified radars and fire-control units. The People's Republic of China planned to purchase this system as part of a modification package for its 'Luda' class destroyers, but the deal was cancelled because of funding problems.

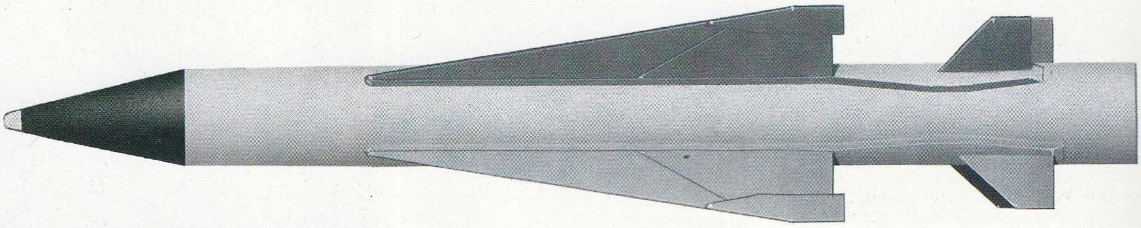
In addition to arming the UK's Type 82 and Type 42 destroyers, Sea Dart is mounted on the three 'Invincible' class aircraft-carriers. It is also used by Argentina on their Type 42 destroyers. A lightweight system has been developed to arm vessels down to only 300 tons.

Specification

Sea Dart
Type: medium-range area-defence missile
Dimensions: length 4.36 m (14 ft 3.65 in); diameter 0.42 m (1 ft 4.54 in); span 0.91 m (2 ft 11.83 in)
Weights: total round 550 kg (1,213 lb); warhead HE-fragmentation
Performance: maximum speed Mach 3+; range 65 km (40.4 miles); altitude limits 30-18290 m (100-60,000 ft)

UK

Sea Wolf



The Sea Wolf missile is 1.9 m (6 ft 3 in) long and weighs 82 kg (180.4 lb). It can be treated as a round of ammunition.

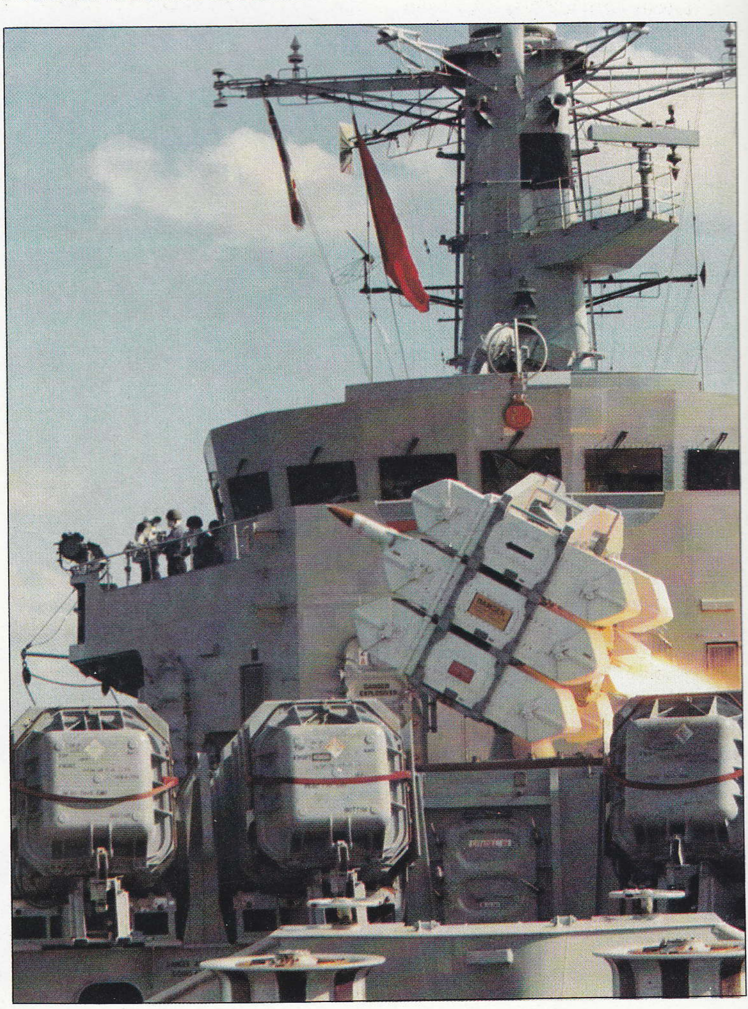
Conceived in 1962 and designed by British Aerospace, the **Sea Wolf** was originally developed as the replacement for the widely-fitted Sea Cat SAM system. Unfortunately, in the **Guided Weapon System Mk 25 Mod 0** devised for the Royal Navy, the weapons package proved so large that it could be fitted on warships only down to the size of 2,500 tons or so. In fact it was the room required to fit two complete manually-reloaded GWS Mk 25 systems with their attendant 30-round magazines and six-round launchers that helped to finalize the dimensions and displacement of the Type 22 frigates in excess of the Sea Dart-equipped Type 42 destroyers.

Sea Wolf is a fully automatic point-defence system with radio command to line-of-sight guidance coupled with radar differential or low light TV tracking. The missile's manoeuvrability and speed allows it to engage small Mach 2 anti-ship missiles and aircraft targets under severe weather conditions and sea states down to low altitudes. During the Falklands war the Type 22 frigates HMS *Brilliant* and HMS *Broadsword*, together with the converted 'Leander' class frigate HMS *Andromeda* with only one launcher, used the missile operationally, one of the Type 22s acting as the close-range air-defence ship or 'goalkeeper' to the carriers. The first combat use was from the *Brilliant* on 12 May when the ship engaged a flight of four McDonnell Douglas A-4 Skyhawks, shooting down two and forcing a third to crash as it evaded a missile. The official list credits the Sea Wolf with five kills, although recent evidence now suggests it was only the three described above, plus a possible fourth. What actually came out of the war was that the system required a number of software upgrades to increase its reliability: on several occasions the computers associated with target-tracking broke lock because they had what was akin to a nervous breakdown trying to differentiate between targets flying close together.

The modifications culminated in a successful trial whereby a Sea Wolf engaged and destroyed a sea skimming MM.38 Exocet anti-ship missile. Further to improve the missile's capabilities and range, a vertical-launch capability, first demonstrated in 1968 from HMS *Loch Fada* when it was considered to be of low priority, will be used aboard the new Type 23 'Daring' class frigates when they are eventually ordered. In the meantime several lightweight systems have also been developed, the **GWS Mk 25 Mod 3** version being retrofitted in one form or another to various RN ship classes to increase their self-defence capability. Another variant which surprisingly the Royal Navy did not follow up was the conversion of the standard four-round Sea Cat launcher to take Sea Wolf container-launchers (together with the fitting of appropriate electronics and radars). Such a programme for the frigates of the Royal Navy would have undoubtedly resulted in a much higher kill rate for the close-range air-defence systems aboard Royal Navy ships in the Falklands than was in fact obained. To date no other nation has bought this unique missile system.

Specification

Sea Wolf
Type: point-defence missile
Dimensions: length 1.90 m (6 ft 2.8 in); diameter 0.30 m (11.8 in); span 0.45 m (1 ft 5.7 in)
Weights: total round 82 kg (180.4 lb); warhead ? HE-fragmentation
Performance: maximum speed Mach 2+; range 6.5 km (4.04 miles) or 10 km (6.2 miles) in vertical-launch form; altitude limits about 4.7-3050 m (15-10,000 ft)



A Sea Wolf missile is launched from a Type 22 frigate. The missile is highly effective, but with ancillary radar, launch and command systems the Sea Wolf system is rather heavy, and to operate two launchers effectively the Type 22 frigates have to be larger than Type 42 destroyers.

SAMs in Action in the Falklands

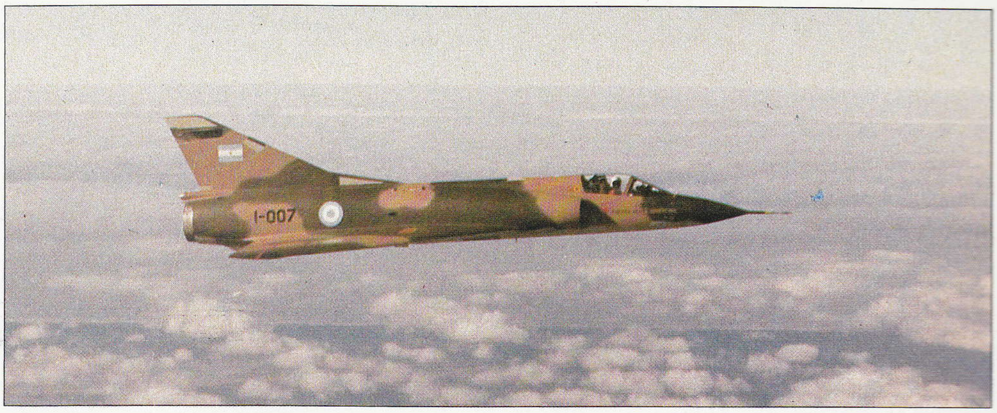
For all the widespread adoption of surface-to-air missiles in the navies of the world, the only occasions where they have seen operational service have been in Vietnam (where US long-range missiles scored against enemy aircraft), and the Falklands, where for the first time a missile-armed fleet came up against determined large-scale attack.

The 1982 Falklands war was the first real test of a modern surface fleet's layered defence concept, using aircraft in the outermost defence zone and medium-range SAMs in the middle zone before hostile aircraft can reach the final close-range inner zone, defended by short-range shipborne missiles, medium- and light-calibre anti-aircraft guns and small arms.

The first combat use of SAMs during Operation 'Corporate' was on 9 May 1982, when the Type 42 destroyer HMS *Coventry* and the Type 22 frigate HMS *Broadsword* were operating off Port Stanley. The Type 965 air search radar of the *Coventry* picked up a slow-moving hostile airborne target near the town and engaged it with a Sea Dart missile. This exploded close to an Argentine army Aérospatiale SA 330 Puma helicopter, causing it to crash with the loss of all aboard. Three days later, on 12 May, came the turn of the destroyer HMS *Glasgow* and the frigate HMS *Brilliant*, sister ships of the previous vessels. Two four-plane flights of McDonnell Douglas A-4B Skyhawks from the Argentine air force's Grupo 5 swooped in to attack the ships just after midday as they took part in a bombardment of Port Stanley airfield. The leading wave was engaged by the *Brilliant*'s Sea Wolf systems, which sent two aircraft cartwheeling out of the sky in flames and forced a third to crash as it tried to evade a missile. As the surviving Skyhawk pulled away the second flight attacked, three aircraft heading for the *Glasgow* and one for the *Brilliant*. Again the Sea Wolf system prepared to engage, but as the missiles were about to be launched the fire-control computer suddenly switched off the automatic engagement sequence, leaving the ship wide open. In what can only be described as a miraculous escape the bombs meant for the *Brilliant* fell short, one then bouncing over the top of the ship's superstructure.

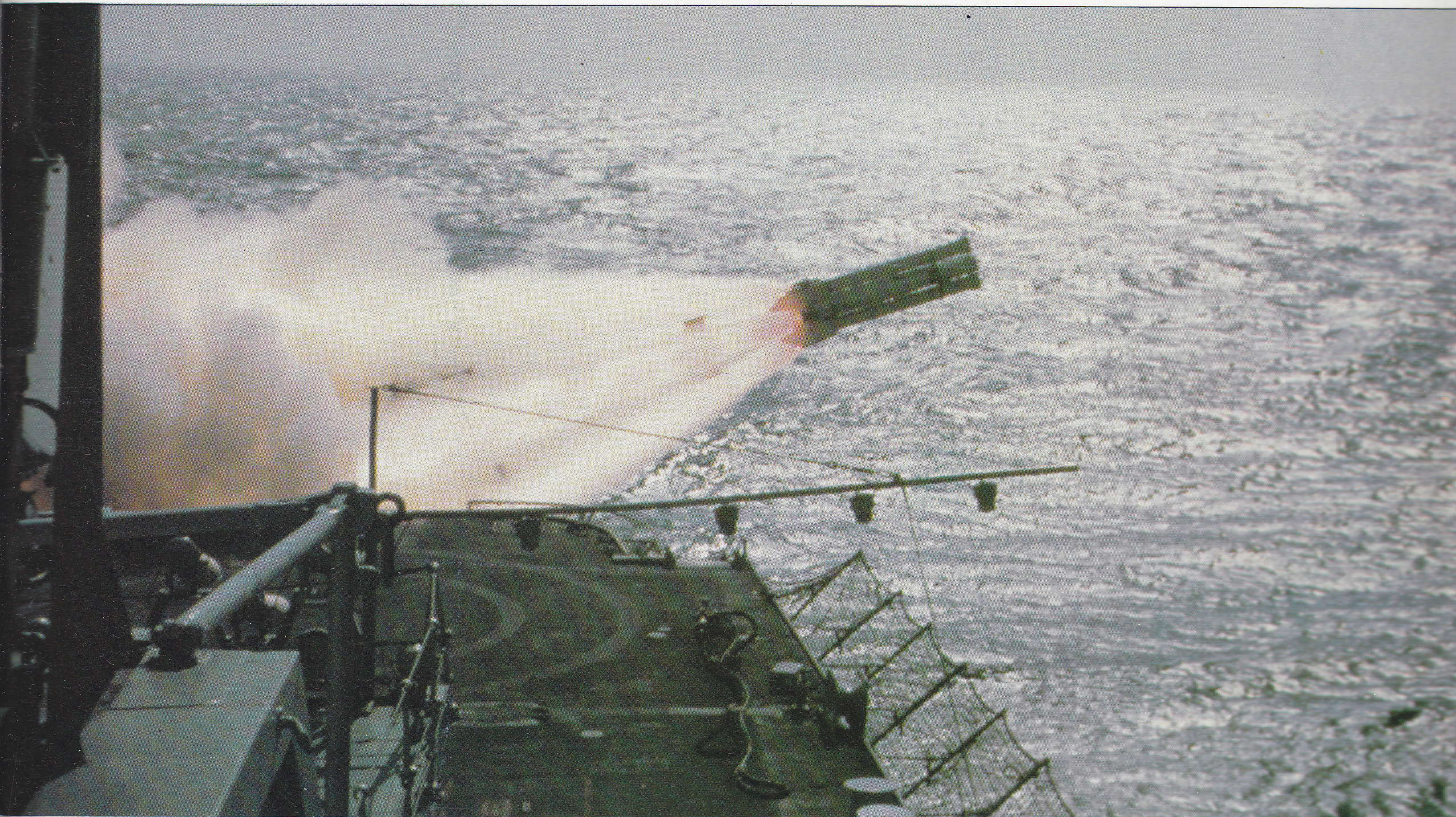
In the meantime the *Glasgow*, unable to engage with her Sea Dart system, survived a direct hit from a 454-kg (1000-lb) bomb that passed straight through her hull from one side to the other before exploding in the sea beyond several seconds later. However, the damage proved severe enough for the *Glasgow* to have to withdraw from the operational zone. As a result of this attack, Admiral Woodward decided that there would be no more naval bombardments of the airfield during daylight hours.

The next test for the missile defences came during the 21 May amphibious landings at San Carlos. Standing combat air patrols of BAe Sea Harriers were established to the north west and south west of the landing area at a distance of 48 km (30 miles) whilst a 'gun line' of warships was established to screen the area. Any aircraft leaking through these cordons were engaged by the close-range defences of the warships and amphibious vessels, plus any other weapon handy. During the numerous air attacks of that day by Argentine air force and naval aircraft, all the Royal Navy's SAM systems were used. At the end of the day the Type 21 frigate HMS *Ardent* was left sinking, whilst at



***Above:** The first problem faced by the British was that any assault on the Falklands would have to cope with the substantial threat posed by the skilful pilots of the Argentine armed forces, flying A-4 Skyhawks or (as here) the Dassault Mirage.*

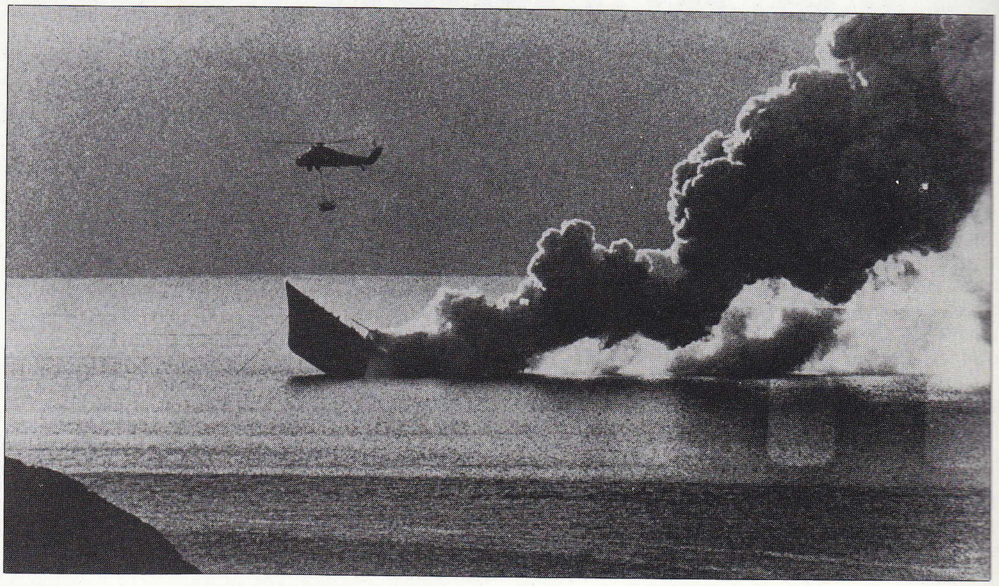
***Below:** The only ships fitted with Seaslugs in the South Atlantic were the 'County' class destroyers HMS* Antrim *and* Glamorgan*. A first-generation, beam-riding weapon, Seaslug saw its first (and probably its last) action in the campaign.*



least four other warships had suffered damage (ranging from light to severe) in the restricted waters. Although several kills were claimed by the SAMs over the bridgehead a recent post-war analysis suggests that in fact they only hit one IAI Dagger which fell to Sea Cats launched from the frigates HMS *Argonaut* and HMS *Plymouth*. The numerous other missiles launched were not fired in vain, as they certainly succeeded in turning back Argentine air attacks and preventing accurate bombing.

On 23 May the Argentines came back to the beach-head with more heavy strikes that left several other ships damaged, including the frigate HMS *Antelope* with two unexploded bombs inside her. An A-4B Skyhawk of Grupo 5 was lost to hits from a Sea Wolf from the *Broadsword* (and possibly a shore-based Rapier), and the number of kills claimed by the naval missiles was again much greater than those of shore-based SAMs. The *Antelope* subsequently sank during that night after one of the bombs exploded as it was being defused.

The following day was a repeat of 23 May, with heavy defensive missile fire and anti-aircraft gunfire directed at the low-level attackers. Several aircraft were claimed by the missiles. None were actually lost, although the Argentines have admitted that several aircraft suffered severe battle damage before regaining their bases. The next day, 25 May, was expected to be a maximum-effort day for the Argentines as it is their national day. For this a missile trap (a Type 42 destroyer, the *Coventry*, and a Type 22 frigate, the *Broadsword*) was deployed to a point near Pebble Island to catch the enemy aircraft before they dropped to very low level for the final run-in. The ships nearly caught several Learjet 35A reconnaissance aircraft of Grupo 2 in the morning on a high-level photographic run over the beach-head, but as the Coventry attempted to launch her Sea Darts the Learjets flew out of range. The Learjets were followed until mid-day by small flights of Skyhawks attacking at low level the ships at anchor in San Carlos Water. The intense defensive fire resulted in the loss of two A-4C Skyhawks from Grupo 4 to combined fire from several systems including Sea Cat and Sea Wolf missiles. Then just after 14.00 the missile trap ships came under attack by four A-4B Skyhawks from Grupo 5. Two aircraft went for each ship. The pair heading for the *Broadsword* dropped four bombs, of which one scored a direct hit after bouncing off the water; but this failed to explode even after demolishing the front of the *Broadsword*'s Westland Lynx helicopter. The ship's Sea Wolf fire-control system broke lock at the critical pre-launch moment before she could destroy her attackers. At the same time the other pair closed the *Coventry*, which fired a Sea Dart at them and missed. The *Broadsword* took up the engagement but just as she was going to fire the *Coventry* cut across her bows, shielding the Skyhawks and causing the radar to break lock again. The *Broadsword* could then only look on helplessly as three direct hits blew the port side out of the *Coventry*, causing her to capsize and sink. The final attack of the day went in against the carrier task group later in the afternoon, when two Exocet-armed Dassault-Breguet Super Etendards of the Argentine navy fired their AM.39 missiles, hitting the



***The penalty for misjudging the Argentine threat was severe. In the face of determined, skilful low-level attack and in the absence of any AEW, even the best defence can prove penetrable, as tragically shown by HMS* Antelope.**

The most capable missile system in use in the battle was Sea Wolf. It destroyed a number of attacking aircraft, but operations exposed some technical faults needing urgent remedies.

Operations in the waters around the Falkland Islands saw the Royal Navy firing more missiles in two months than would otherwise have been fired by the units involved in several years. Such intensive operations provided valuable information for future developments, in addition to the main aim of recapturing the islands.

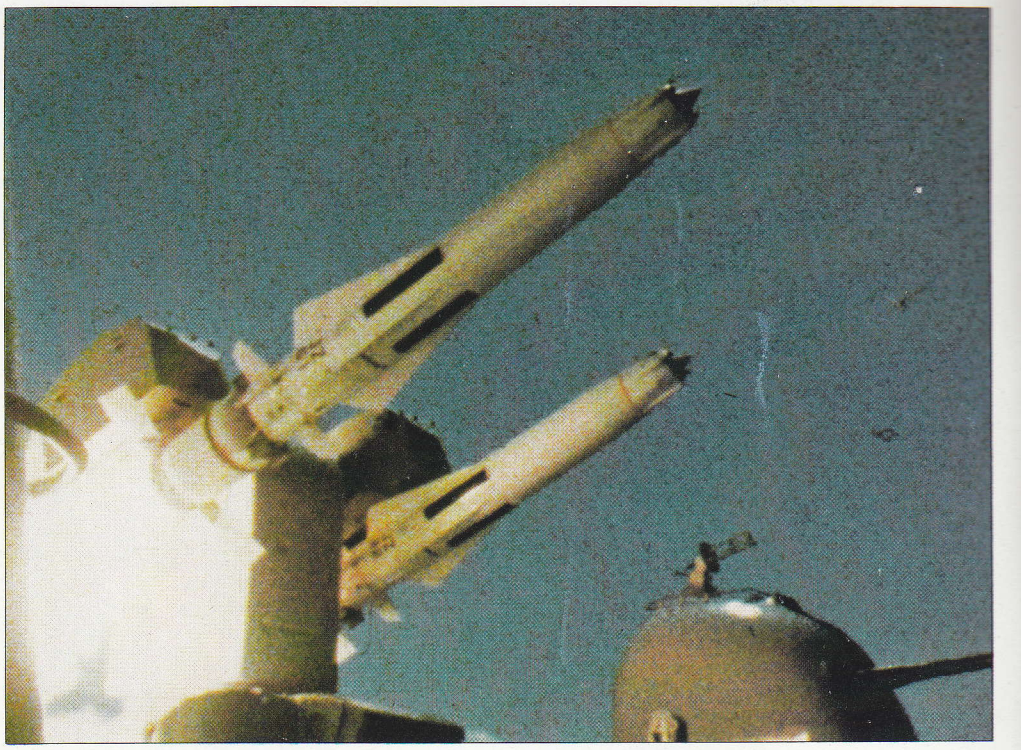
SAMs in Action in the Falklands

Atlantic Conveyor. During this attack HMS *Invincible* alone fired no less than six Sea Darts in less than two minutes without hitting anything but in the process scaring HMS *Hermes*' crew almost to death as one SAM passed close to their ship.

On 27 May a further high-level photo run over San Carlos was made by the Learjets, but no response from the Sea Darts came as the ships fitted with the system were with the carriers away to the east. It was whilst working with them that the Type 42 destroyer HMS *Exeter* engaged the second Argentine attack on the group on 30 May when with a left and right from her launcher she destroyed two low-flying A-4Cs from Grupo 4 that were backing up the Exocet attack. The missiles actually hit the aircraft outside their engagement envelope. The Sea Dart's high-altitude capability was finally tested on 6 June when the third photo reconnaissance run by Learjets of Grupo 2 was countered by a launch of two Sea Darts from the *Exeter*. One failed in flight but the other blew the tail off the leading Learjet at a height of 12000 m (39,370 ft), causing it to crash with the loss of its crew of five. The engagement also showed the limitation of Sea Dart in that a second engagement could not start until the first was finished.

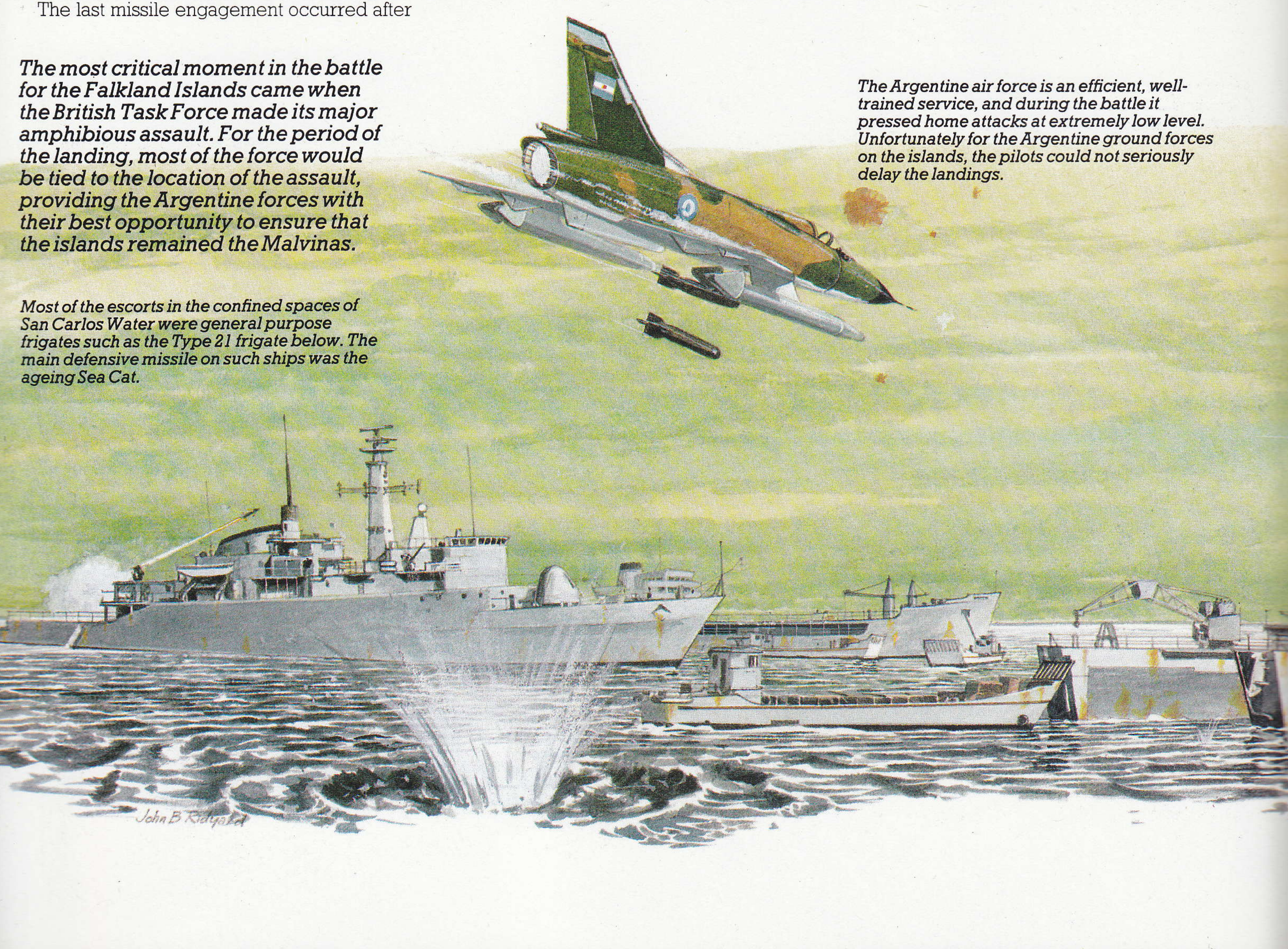
On 8 June, the day of the Bluff Cove tragedy, HMS *Plymouth* keenly felt the lack of modern air defence systems when her Sea Cats and guns failed to save her from severe damage caused by an attack by five Grupo 6 Daggers.

The last missile engagement occurred after



Above: Sea Dart was used on several occasions, but Argentine familiarity with the system (which arms their two Type 42 destroyers) ensured that most attacks were made outside the missile's performance spectrum, with the result that Sea Dart was not as successful as had been expected.

The most critical moment in the battle for the Falkland Islands came when the British Task Force made its major amphibious assault. For the period of the landing, most of the force would be tied to the location of the assault, providing the Argentine forces with their best opportunity to ensure that the islands remained the Malvinas.



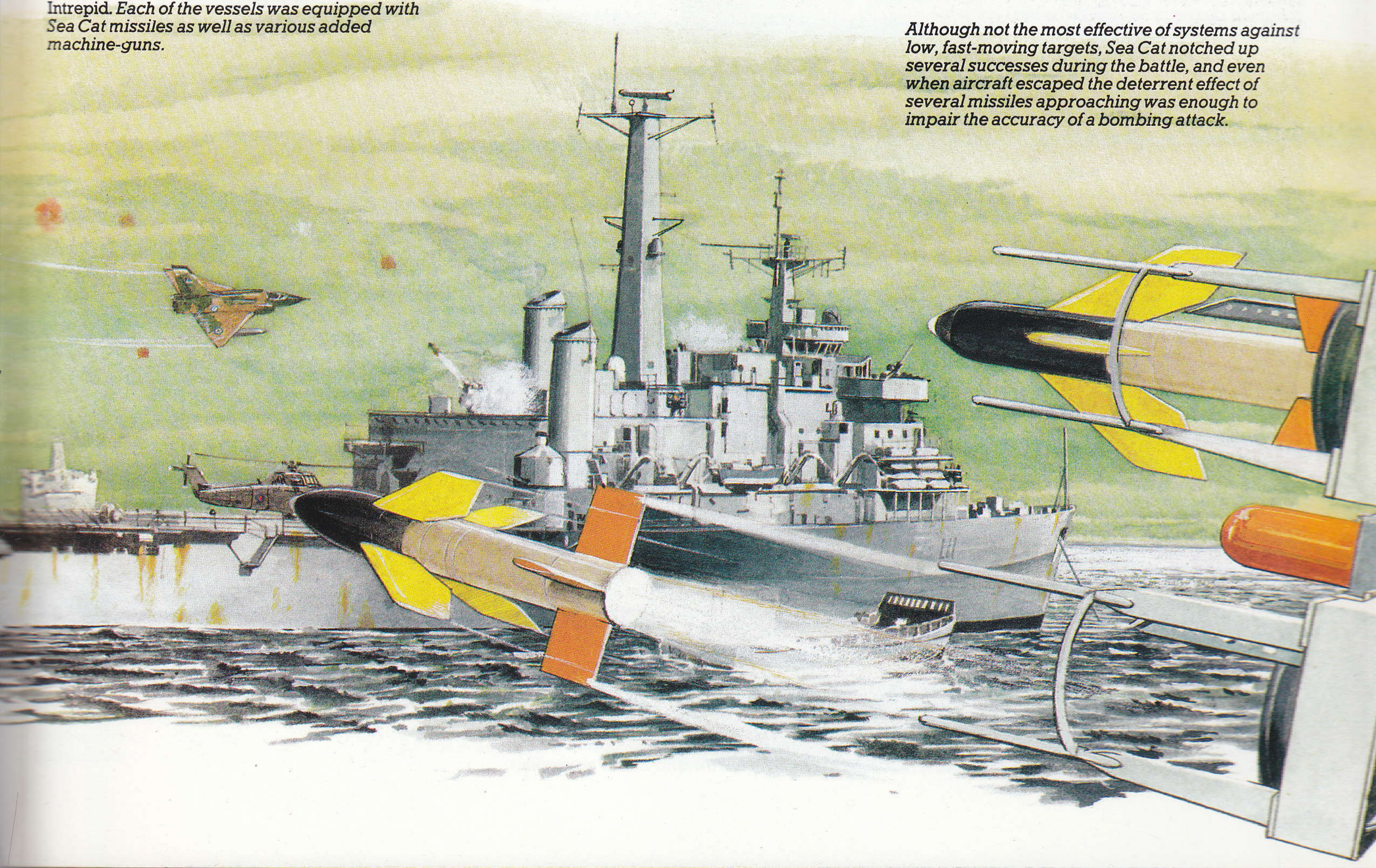
The Argentine air force is an efficient, well-trained service, and during the battle it pressed home attacks at extremely low level. Unfortunately for the Argentine ground forces on the islands, the pilots could not seriously delay the landings.

Most of the escorts in the confined spaces of San Carlos Water were general purpose frigates such as the Type 21 frigate below. The main defensive missile on such ships was the ageing Sea Cat.

dark on 13 June when the *Exeter* blew a BAe Canberra B.Mk 62 light bomber out of the sky with a Sea Dart as she bombed Mount Kent from 12000 m (39,370 ft).

Although they did not destroy as many aircraft as claimed in the White Paper on the war, the naval SAMs were more effective than guns in the Falklands. The Sea Dart (when available at the San Carlos beach-head) forced the majority of the attackers to fly low level and limited the high-level reconnaissance and bombing missions. However, the war also showed up the Sea Dart's weaknesses in fire-control and computer-launch areas. On the other side of the coin experience revealed that the Sea Dart could be used outside its nominal launch envelope against low-flying targets. The Sea Wolf, although suffering a number of software failures during critical saturation attacks, nevertheless proved to be an excellent defence system at short ranges, although its use in defending other ships was found to be limited. The most numerous missile system, the Sea Cat, showed itself to be somewhat long in the tooth for modern naval warfare, numerous instances being recorded of the missile running out of fuel just as it was going to hit a target. However, it did fulfil its purpose in helping to prevent accurate air attacks when it was used in conjunction with other systems. Hopefully most of the shortcomings revealed in the systems have now been rectified. It cannot be denied that lack of money (and, in some instances, foresight before the war) certainly contributed to these failings in one way or another.

Above: At the start of the operation, guns were not expected to be of any great use in defending the fleet, which proved to be a considerable error of judgement. Indeed, experience has shown that a combination of guns (such as the 20-mm Oerlikon shown) and missiles is most effective.



Major targets for the Argentine attacks were the specialized assault ships HMS Fearless *and* Intrepid. *Each of the vessels was equipped with Sea Cat missiles as well as various added machine-guns.*

Although not the most effective of systems against low, fast-moving targets, Sea Cat notched up several successes during the battle, and even when aircraft escaped the deterrent effect of several missiles approaching was enough to impair the accuracy of a bombing attack.

USSR

SA-N-1 'Goa' and SA-N-7

The two-stage solid propellant **SA-N-1a 'Goa'** entered Soviet navy service in 1961 and was the first naval SAM to be fitted extensively in Soviet surface combatants. It is derived from the ground-launched SA-3a 'Goa', and is considered to be an effective missile at low to medium altitudes, and in the surface-to-surface role out to the radar horizon. It is a medium-range area-defence weapon that is fired from a twin-arm launcher which is rotated to the 90° vertical position for reloading from an under-deck 16-round magazine. The four rectangular fins are folded until the missile leaves the launcher. An HE-fragmentation or 10-kiloton nuclear warhead can be fitted, the former having a 12.5-m (41-ft) lethal burst radius at low levels against targets the size of the McDonnell Douglas F-4 Phantom. Guidance is by radio command, although the latest uprated versions of the 'Peel Group' naval fire-control radar array associated with the missile have been converted for semi-active terminal homing for use with the **SA-N-3b 'Goa'** variant. The 'Goa' is also used by India and Poland.

In 1981 the long-term replacement for the SA-N-1 system, the **SA-N-7**, went to sea aboard the 'Kashin' class trials ship *Provorny* and on the new 'Sovremenny' class of missile destroyers. The new missile is a navalized version of the Soviet army's Mach 3 SA-11 and uses a single-arm launcher with six or eight associated 'Front Dome' target-illuminating radars for the missile's semi-active radar terminal guidance system. The SA-N-7 has a conventional HE warhead and is capable of engaging targets between the altitude limits of 30 to 14000 m (100 to 45,930 ft) between the maximum and minimum ranges of 28 km (17.4 miles) and 3 km (1.86 miles) respectively.

Specification

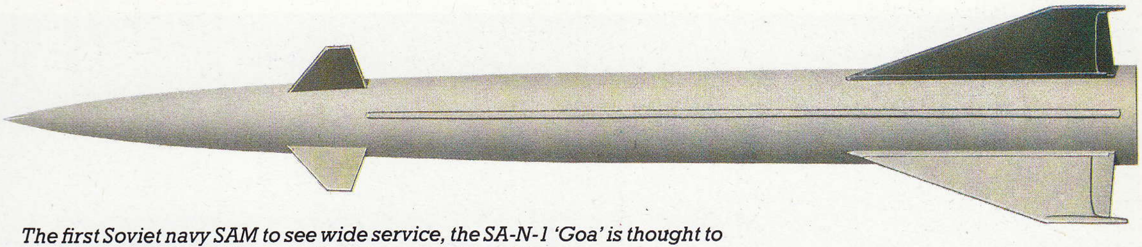
SA-N-1 'Goa'

Type: medium-range area-defence missile

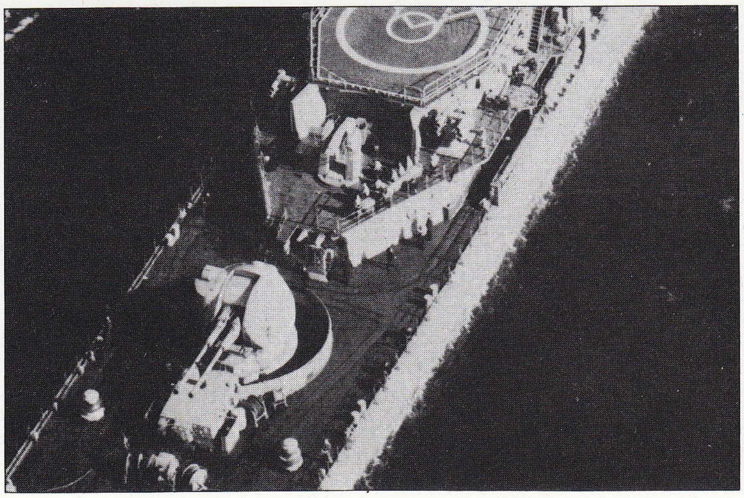
Dimensions: length 6.70 m (21 ft 11.8 in); diameter of missile 0.46 m (1 ft 6.1 in) and of booster 0.701 m (2 ft 3.6 in); span of missile 1.50 m (4 ft 11.1 in)

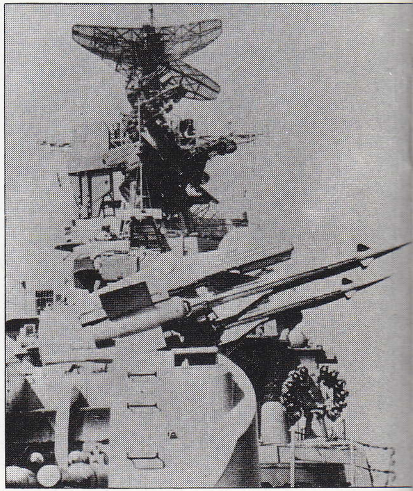
Weights: total round 946 kg (2,085.5 lb) for SA-N-1a and 950 kg (2,094.4 lb) for SA-N-1b; warhead 60-kg (132-lb) HE or 10-kiloton nuclear

Performance: maximum speed Mach 2.1; range 6-22 km (3.7-13.7 miles); altitude limits 90-15250 m (295-50,030 ft)



The first Soviet navy SAM to see wide service, the SA-N-1 'Goa' is thought to have been developed from the land-based system of the same name.

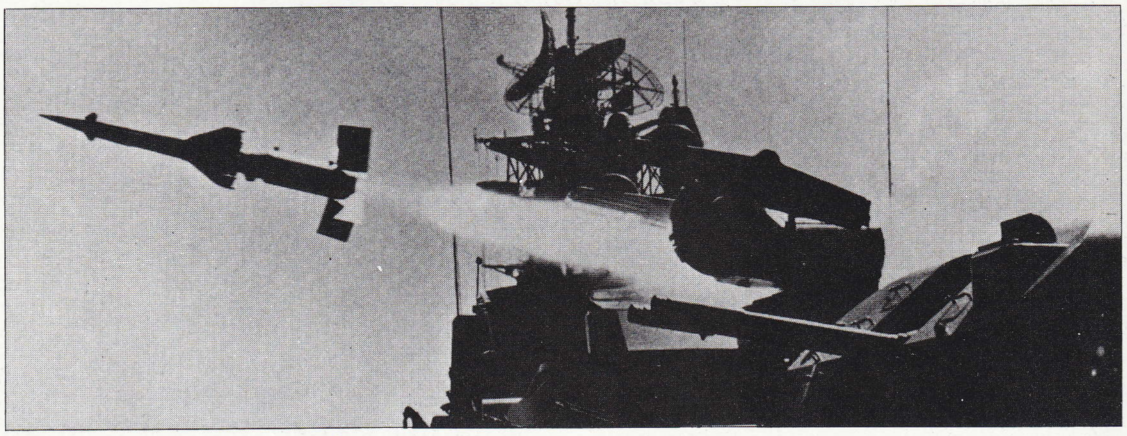




Below: A 'Kashin' class destroyer launches an SA-N-1 Goa. The engagement envelope of the Mach 2.1 missile is between 6 and 22 km (3.7-13.7 miles) at heights ranging from 90 to 15250 m (295-50,030 ft). The 60-kg (132-lb) warhead can be high explosive or low-yield nuclear.

Above: Visible behind the twin 130-mm gun mount on the Soviet destroyer Sovremenny, *the single-rail launcher for the SA-N-7 is thought to be capable of rapid reloading and firing. The presence of six separate fire control radars implies a multiple target system.*

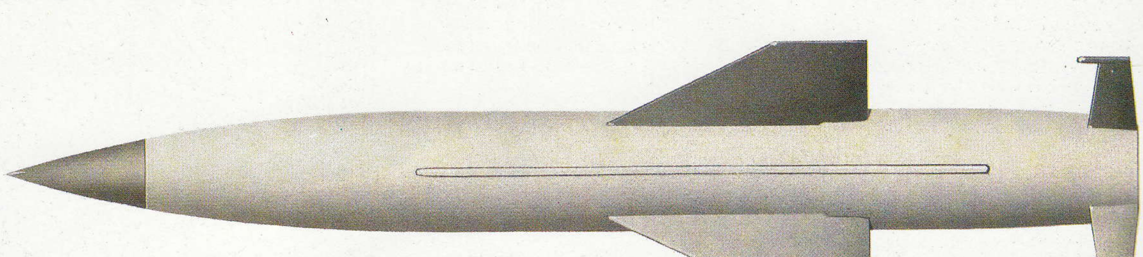
Above: The twin-rail SA-N-1 launcher aboard a 'Kashin' class destroyer is roll-stabilized to give stable launch conditions in rough sea states. There are over 60 systems in use on 'SAM Kotlin', 'Kanin', 'Kynda', 'Kashin' and 'Kresta 1' class vessels, the last two classes having two twin launchers.



USSR

SA-N-3 'Goblet' and SA-N-6

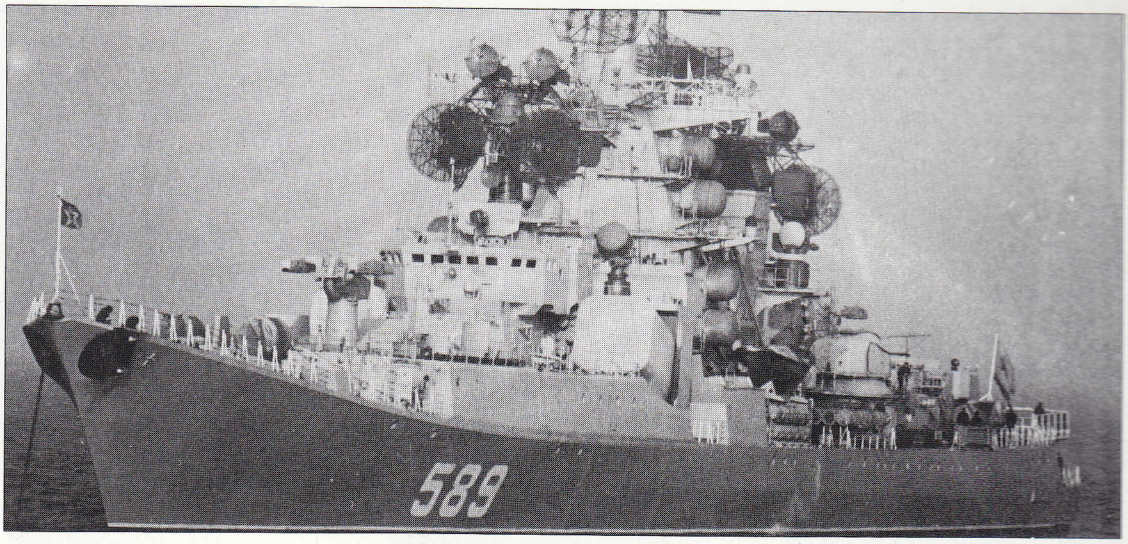
The two-stage solid-propellant **SA-N-3 'Goblet'** entered service in 1967 as the second-generation medium-range low/medium-altitude area-defence follow-on to the SA-N-1 'Goa' system in Soviet navy service. With improved anti-air warfare capabilities, the SA-N-3 can also be used in the surface-to-surface role out to the radar horizon. Unlike other contemporary Soviet navy SAMs it has no Soviet army equivalent, and is not derived from the SA-6 'Gainful' as often stated. The SA-N-3 may be fitted with either an HE-fragmentation or a 25-kiloton nuclear warhead, and is fired from a twin-arm



A generation further on from the SA-N-1, the SA-N-3 'Goblet' is a Mach 2.8 missile that does not seem to have a land-based equivalent.

launcher, the system rotating to the vertical for reloading from an underdeck magazine. The proportion of missiles fitted with nuclear warheads in the ship's outfit has been assessed by some sources as 25 per cent. Guidance is by radio command via 'Head Light' series fire-control radar array. The 'Goblet' is fitted to 'Kresta II' and 'Kara' class missile cruisers as well as to the 'Moskva' and 'Kiev' classes of aviation ships.

In 1978 the replacement system, the **SA-N-6**, entered service on the 'Kirov' nuclear-powered cruiser class as part of what is now known to be a Soviet AEGIS-style SAM area-defence system for surface task groups. The single-stage missile is vertically launched from silos served by eight-round rotary magazines, and is an advanced high-performance SAM adapted from the Soviet army's SA-10 specifically to provide the navy with a missile that has extensive anti-cruise missile capabilities. Missile guidance is semi-active for the mid-course phase (with target-illumination from the 'Top Dome' radar) and then active radar for the terminal phase to give a much more accurate interception. The system has since entered service on the 'Krasina' class missile cruisers, which have a slimmed-down version of the missile fitted to the *Kirov*. The 7.0 m (22 ft 11.6 in) long solid-propellant Mach 6 missile has a 100 kg (220 lb) conventional HE warhead and can engage targets between 10 m (33 ft) and 30500 m (100,065 ft) at ranges between 9.6 and 64 km (6 and 40 miles).



Specification

SA-N-3 'Goblet'

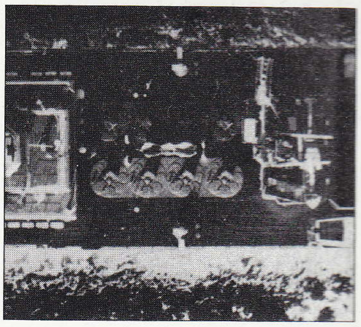
Type: medium-range area-defence missile

Dimensions: length 6.40 m (21 ft 0 in); diameter 0.70 m (2 ft 3.6 in); span 1.70 m (5 ft 6.9 in)

Weights: total round not known; warhead 150-kg (331-lb) HE or 25-kiloton nuclear

Performance: maximum speed Mach 2.8; range 6-30 km (3.7-18.6 miles) in early versions or 6-55 km (3.7-34 miles) in later versions; altitude limits 90-24500 m (295-80,380 ft)

Above: The large twin-rail launcher aboard 'Kresta II' class cruisers may be a dual purpose system, capable of firing SS-N-14 anti-submarine missiles as well as the SA-N-3. The system is also fitted to the 'Kiev', 'Kara' and 'Moskva' classes.



Right: The hatch covers over the vertical launch system aboard the Soviet cruiser Slava *conceal eight-round rotary magazines for the SA-N-6 missiles carried. The SA-N-6 has also been fitted to the 'Kirov' class cruisers as an anti-missile system.*

USSR

SA-N-4 'Gecko' and SA-N-8

The single-stage solid-propellant **SA-N-4 'Gecko'** entered service in the early 1970s as the Soviet navy's point-defence missile system for both large and small surface combatants. Based on the Soviet army's SA-8, the SA-N-4 uses a fully retractable twin-arm launcher with an 18-round under-decks missile magazine. The missile has an HE warhead and can be used out to its maximum range as a surface-to-surface missile in emergency. Its guidance is of the command type via the 'Pop Group' fire-control radar system associated with each launcher. Unlike other modern Soviet naval SAMs the 'Gecko' has been widely exported to a number of Soviet client states as part of the armament outfit for export versions of the 'Nanuchka' missile corvettes and 'Koni' class light frigates.

In the early 1980s a new vertically-launched point-defence SAM system, the SA-N-8, went to sea aboard the 'Udaloy' class of anti-submarine destroyer and the third and fourth of the 'Kiev' class aviation ships. The missile is a short/medium-range weapon. of high performance with a semi-active or active radar-homing guidance system. No other details have been released at present.

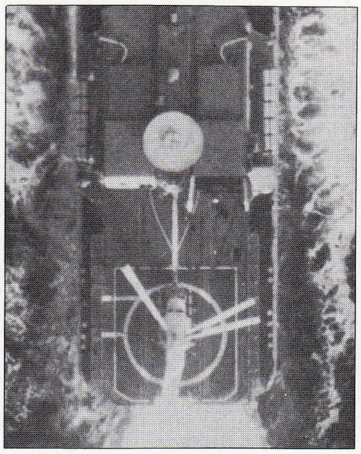
Specification

SA-N-4 'Gecko'

Type: point-defence missile

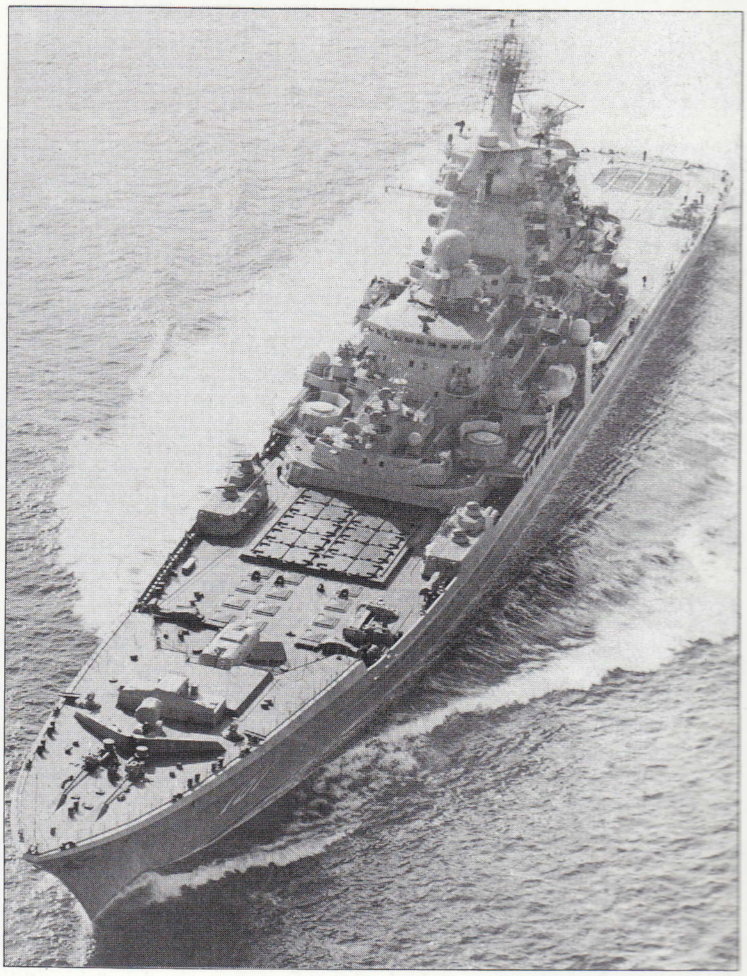
Dimensions: length 3.20 m (10 ft 6 in); diameter 0.21 m (8.25 in); span 0.64 m (2 ft 1.2 in)

Weights: total round 190 kg (418.9 lb); warhead 50-kg (110-lb) HE-fragmentation



Above: Little is known of the SA-N-8 system, other than the fact that it is a short- to medium-range system and may be active radar homing. First deployment is in the Udaloy *large ASW destroyer, with pop-up systems fore and aft.*

Right: In addition to the potent SA-N-6 in its vertical launchers, the Kirov *has two 'pop-up' missile systems firing the point defence SA-N-4 'Gecko'. The two bandstand-like launcher covers are visible in front of and to either side of the bridge.*



Performance: maximum speed Mach 2; range 1.6-12 km (1-7.5 miles); altitude limits 50-13000 m (165-42,650 ft)

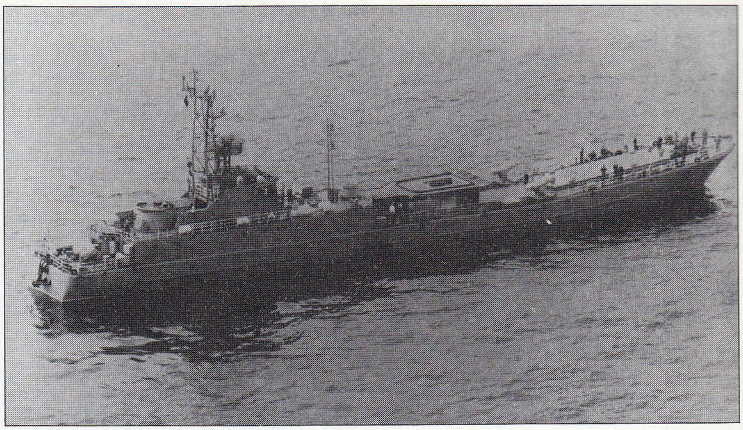
USSR

SA-N-5 'Grail'

The solid-propellant single-stage **SA-N-5 'Grail'** is the shipborne version of the Soviet army's shoulder-launched SA-7b short-range IR-homing SAM. The Soviets give the missile system the designation **9M32M** and the missile the designation **Strela 2M**. It is fitted aboard various small combatants, amphibious warfare vessels and auxiliary ships as a four-round pedestal mount with an adjacent reload locker containing a further four or eight launchers. The shoulder-launched version is also used by the Soviet Naval Infantry from the decks of amphibious warfare vessels and by other nations such as East Germany, Egypt, Israel and Syria from fast attack craft. The missile relies upon a pursuit interception to engage low-flying aircraft, and has proved especially effective against helicopters and slow-flying fixed-wing aircraft such as observation planes. A simple optical sight and tracker unit is used for both types of mounts, the IR seeker being activated when the operator has acquired the target. An indicator light (denoting seeker acquisition) tells the operator when he is free to launch the missile. In order to defeat flare countermeasures, filters have been installed in the seeker. The SA-N-5 uses an increased-thrust propellant to give a greater range and speed in comparison with the earlier SA-7a.

Specification

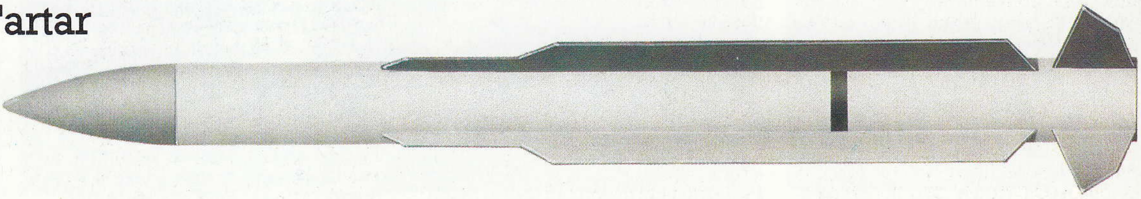
SA-N-5 'Grail'
Type: point-defence missile
Dimensions: length 1.29 m (4 ft 2.8 in); diameter 0.07 m (2.76 in); span not known
Weights: total round 9.2 kg (20.3 lb); warhead 2.5-kg (5.5-lb) HE-fragmentation
Performance: maximum speed Mach 1.95; range 4.8 km (3 miles); altitude limits 45-4800 m (150-15,750 ft)



The SA-N-5 Grail is a simple adaptation of the SA-7 man-portable infra-red guided missile. The 'Polnocny' class landing ship shown has its two four-round launching posts amidships just ahead of the platform. On deck astern of the posts can be seen the reload lockers.

USA

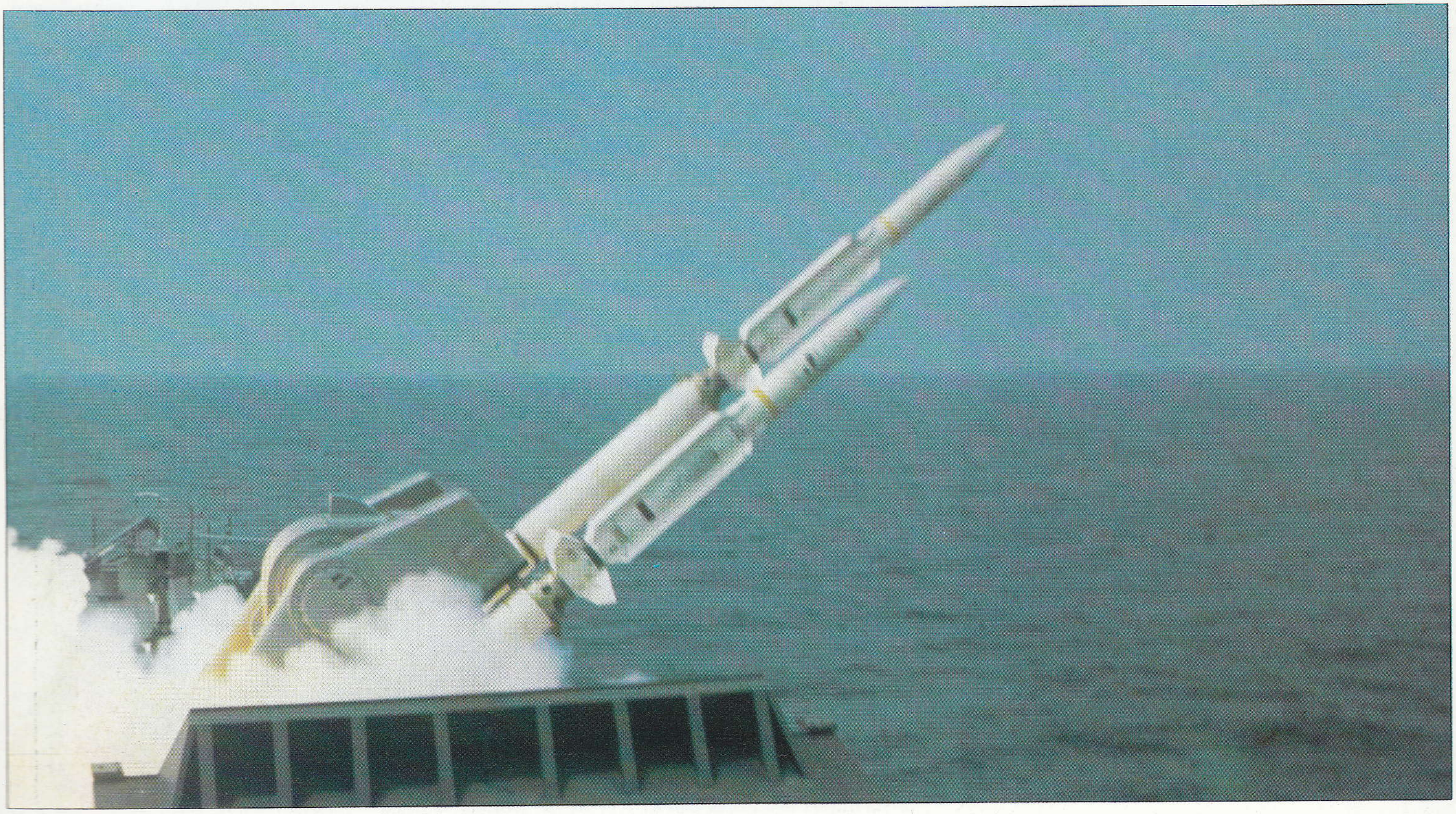
Terrier and Tartar



One of the earliest generations of naval surface-to-air missiles, Tartar was supplied to the navies of the USA, Australia, France, Italy, Japan, the Netherlands and the Federal Republic of Germany.

The **Terrier** area-defence missile was developed from the technology involved in the Talos missile programme, but actually preceded that missile into service. Compared with Talos the Terrier was much more compact, being small enough to be fitted aboard the missile frigates or large destroyers that were being constructed to carry missile systems. Since the start of its development in 1949, the Terrier has evolved gradually over the years with only one major component at a time varied to produce new variants. The original Mach 1.8 beam-riding missile was designated **BW-0** (later **RIM-2A**) with range limits of 18.5 km (11.5 miles) and altitude limits of 1525-15240 m (5,000-50,000 ft). The next version, the **BW-1** (**RIM-2B**), was a re-engineered BW-0 but had no significant performance improvements in either range or altitude. In 1956 there entered service the **BT-3** (**RIM-2C**) with new tail controls, improved beam-riding guidance and a new motor propellant. The improvements increased the velocity to Mach 3 and the range and maximum altitude limit by 50 per cent. This was rapidly followed by the **BT-3A** (**RIM-2D**), which added a surface-to-surface capability to the Terrier system when

Terrier has been largely superseded by Standard, but for many years it provided air defence for the US Navy. The RIM-2E, seen launched from the cruiser USS Josephus Daniels *in 1973, had a maximum range in excess of 70 km (43 miles).*

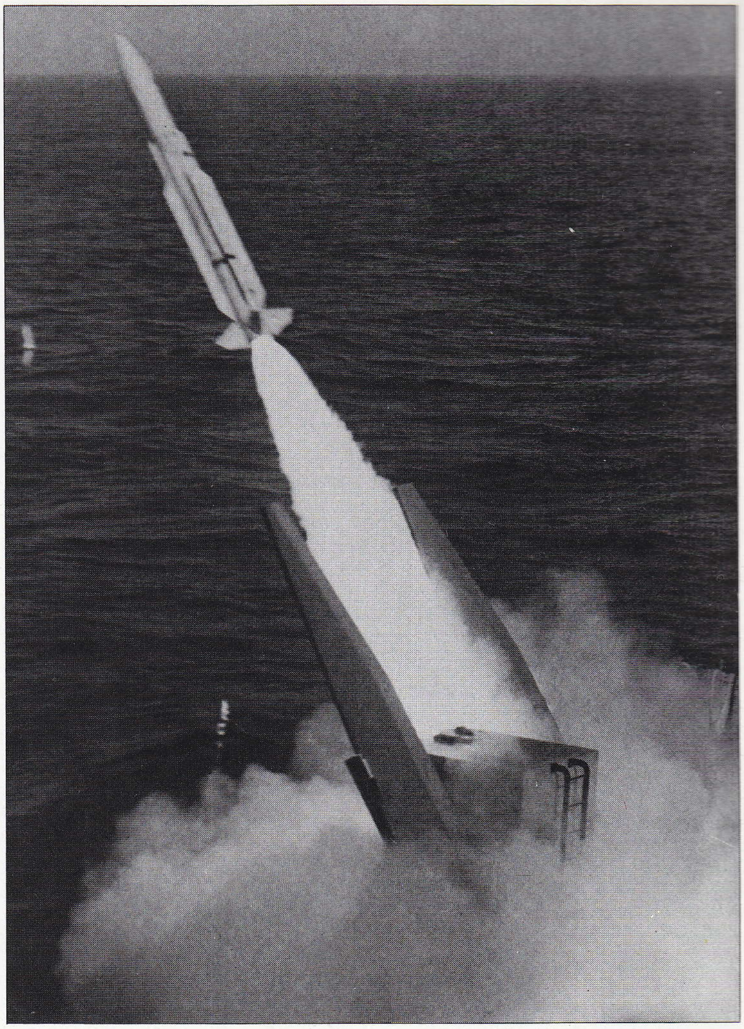


it entered service in 1958 and increased the SAM range to 37 km (23 miles). A nuclear version with the 1-kiloton yield W45 fission type warhead was also produced alongside this variant and designated **BT-3(N)**; in its redesignated **RIM-2D(N)** form this version is still in service on a number of US Navy ships equipped with the Standard SM-1/SM-2ER system. The last planned variant, the **HT-3** (**RIM-2E**), entered service one year earlier than the BT-3 and introduced continuous-wave semi-active homing as the guidance mode, which increased its low-altitude engagement capability and improved the single-shot kill capability figure by over 30 per cent compared with those of the beam-riding variants. The last HT-3 versions, delivered in the mid-1960s, were fitted with a new sustainer and power supply that raised the range to 74 km (46 miles); these missiles were then designated **RIM-2F**. Production of the Terrier ended in 1966 after some 8,000 rounds of all marks had been manufactured. The conventional warhead versions have now mostly been superseded by variants of the Standard missile.

In 1952 a need was appreciated for a semi-active homing missile as a complement to the larger systems to engage low-flying targets and to replace the 127-mm (5-in) gun mount on a one-for-one basis. The result was the basic version of the Mach 1.8 **Tartar** missile (**RIM-24A**), which was effective between ranges of 1.85 and 13.7 km (1.15 and 8.5 miles) and altitude limits of 15 and 16765 m (50 and 55,000 ft). However, a **Product Improved Tartar** was soon sought, the **Improved Tartar** (**RIM-24B**) version entering service in 1963. This had a range increase to 32.5 km (20.2 miles) and an upper altitude engagement limit of 21335 m (70,000 ft). It also has a useful surface-to-surface anti-ship capability. About 6,500 rounds were produced, and most countries that were supplied with the type (Australia, France, Italy, Japan, the Netherlands and West Germany in addition to the USA) have now converted to the Standard missile.

Specification
RIM-2D(N) Terrier
Type: medium-range area-defence missile
Dimensions: length of missile 4.115 m (13 ft 6 in) and of booster 7.874 m (25 ft 10 in); diameter of missile 0.343 m (1 ft 1.5 in) and of booster 0.457 m (1 ft 6 in); span of missile 1.074 m (3 ft 6.3 in)
Weights: missile 535.2 kg (1,180 lb); booster 825.5 kg (1,820 lb); warhead W45 1-kiloton nuclear
Performance: maximum speed Mach 3; range 37 km (23 miles); altitude limits 152-24385 m (500-80,000 ft)

Specification
RIM-24B Improved Tartar
Type: medium-range area-defence missile
Dimensions: length 4.724 m (15 ft 6 in); diameter 0.343 m (13.5 in); span 0.610 m (2 ft 0 in)
Weights: total round 594.2 kg (1,310 lb); warhead ? HE
Performance: maximum speed Mach 1.8; range 32.375 km (20.1 miles); altitude limits 15-21335 m (50-70,000 ft)



First trials of the AEGIS air defence system used Tartar and Terrier missiles while awaiting development of the Standard. A Tartar missile is seen being launched from the trials ship USS Norton Sound *against a supersonic Firebee drone.*

USA

Standard

The semi-active radar homing conventional warhead **Standard** family of naval SAMs started development in the early 1960s as the replacement for the Terrier and Tartar systems. The latter's replacement was the **Standard SM-1MR** (**RIM-66A**), and was designed with an engagement range of 46.35 km (28.8 miles) and an altitude of 45-15240 m (150-50,000 ft). The Terrier's replacement, designated **Standard SM-1ER** (**RIM-67A**) had a range of 74 km (46 miles) and altitude limits of 45-24385 m (150-80,000 ft). After entering service from 1968 onwards in ships undergoing refits and on new-build warships, both missiles have undergone several reliability improvement and performance update programmes. A new dual-thrust motor for the Standard SM-1MR produced the **RIM-66B** missile with a 45 per cent increase in maximum range and a 25 per cent increase in the upper altitude engagement limit. In most cases the changes that have been made have been incorporated as production 'Block' changes which have not given rise to any new designations. The most recent version of the SM-1MR, however, has been given the designation **RIM-66C** or **Standard SM-2MR** as it is the missile designed to operate with the AEGIS air-defence system. The AEGIS system allows for mid-course missile guidance which extends the range of the Tartar-sized missile by 60 per cent to around 74 km (46 miles). A corresponding **Standard SM-2ER** variant or **RIM-67B** is not designed to be fired by AEGIS-equipped ships, although improvements in its booster technology adds a complete Mach number to its velocity to give a kinetic range far outside the current limits of an AEGIS type fire-control system. However, the improvements considerably enhance the weapons' capabilities against high-performance aircraft and missiles. Those ships equipped with Terriers and its Standard SM-1ER replacement have suitable fire-control systems and are getting the Standard SM-2ER.

A low-yield nuclear fission warhead, the W81, is under development for deployment with some 500 or so Standard SM-2MR and SM-2ER missiles from the mid-1980s onwards to replace the Terrier RIM-2D(N). Designated **Standard SM-2(N)**, the missile will become part

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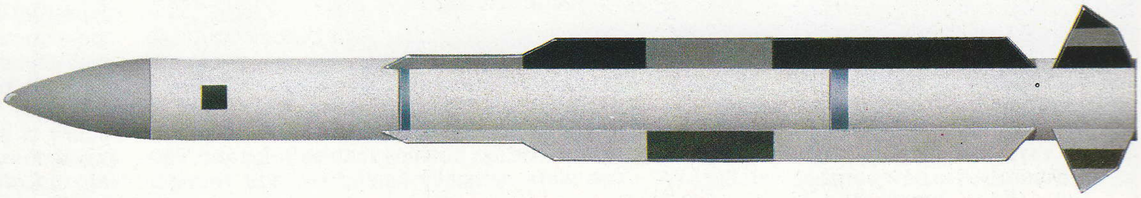
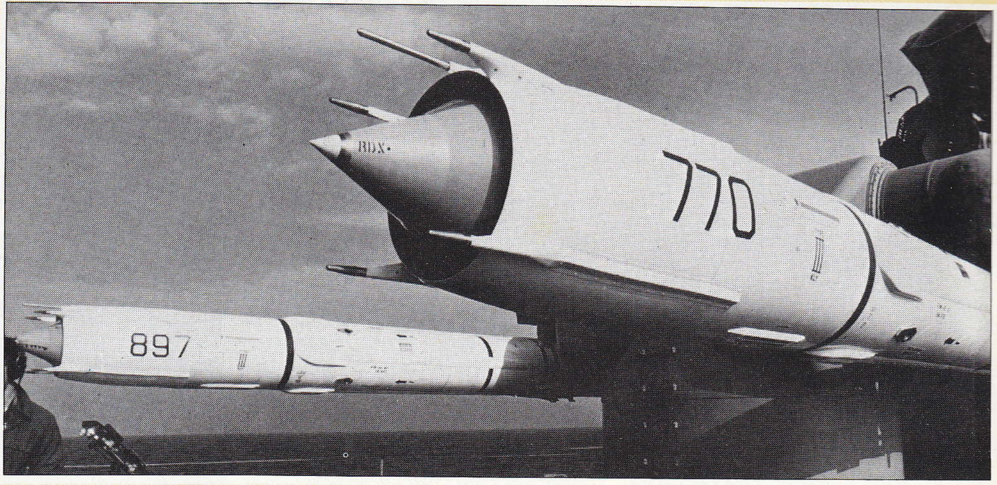


Latest in a line of missiles stretching back to the late 1940s, the Standard missile, in its SM-2 form, is used in the advanced AEGIS system.

Standard SM-2MR missiles are carried aboard the guided.missile trials ships USS Norton Sound*. The SM-2 version of the Standard missile almost doubles the range of the first model, and the greatly uprated electronics of the guidance system ensures improved performance.*

US SAM Development

Surface-to-air missile development by the US Navy has seen a considerable advance in accuracy and capability since World War II. The missile defence of today, notably the highly sophisticated AEGIS system, is a potent force.



Twin Talos missiles are seen aboard the World War II 'Cleveland' class cruiser, converted to guided missile configuration. Talos was used operationally during the Vietnam War, scoring at ranges of over 120 km (75 miles).

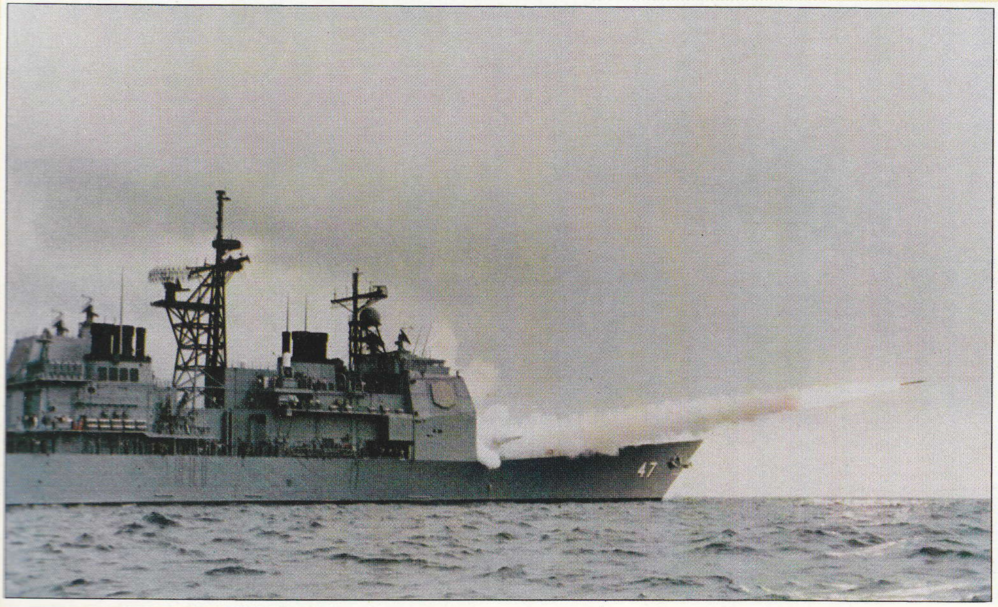
The Talos long-range area-defence SAM was the principal goal of the World War II programme known as 'Bumblebee'. Because of the Americans' lack of ramjet propulsion experience, the missile in its ultimate form was approached in stages. Two of the test vehicles produced were the Experimental Prototype Missile (XPM) and the Supersonic Test Vehicle (STV). The former was developed into the Talos proper whilst the latter evolved into the Terrier missile. As built, the Talos was a beam-rider over most of its range, flying along a radar beam designed to guide the missile along an energy-efficient trajectory until it neared the target, where a semi-active homing seeker took over. This resulted in the missile often impacting the target from above, a factor which produced several tactical surprise situations in Vietnam, where MiG pilots were taught that SAMs always arrived from below. Throughout its service lifetime, from 1957 to 1979, Talos was continually updated: the last version, the RIM-8J, had a range of 249 km (150 miles), which was a considerable improvement over that of the earlier models. The final Unified Talos versions could use either a 5-kiloton W30 nuclear or a 210.9-kg (465-lb) HE-fragmentation warhead. During Vietnam deployments the cruiser USS *Long Beach* scored two MiG kills at extreme range over North Vietnam in 1968, whilst during the mining of Haiphong harbour in April 1972 the cruiser USS *Chicago* added a third kill.

As already indicated, the Terrier was developed from the Talos technology but actually preceded it into service by a year or so. The programme suffered from continual Department of Defense pressure, and for this reason suffered badly from reliability problems in its early stages. Its evolution was therefore gradual, one major element of the guidance system, means of flight control or propulsion motor being varied at a time. Most significant changes resulted in new versions, and the BW-0 (RIM-2A), BW-1 (RIM-2B), BT-3 (RIM-2C), and BT-3A (RIM-2D) were the beam-riding variants while the HT-3 (RIM-2E and RIM-2F) was the semi-active homing variant. A nuclear-armed version of the BT-3A, known as the BT-3(N) or RIM-2D(N), was also built with the 1-kiloton W45 warhead to complement the conventional HE-fragmentation versions.

The third missile of what became known as the 3T-Program was the Tartar, which was envisaged as a shorter-range equivalent of the Terrier to arm destroyer-sized vessels principally against low-flying attackers. Designed from the outset as a semi-active radar homing system, the missile soon underwent a product improvement programme that resulted in the Improved Tartar (RIM-24B) with a considerably enhanced performance envelope. Compared with those of the two other systems, the Tartar's development was rapid, and large numbers of the family were procured for both the US Navy and friendly Western nations.

New technology

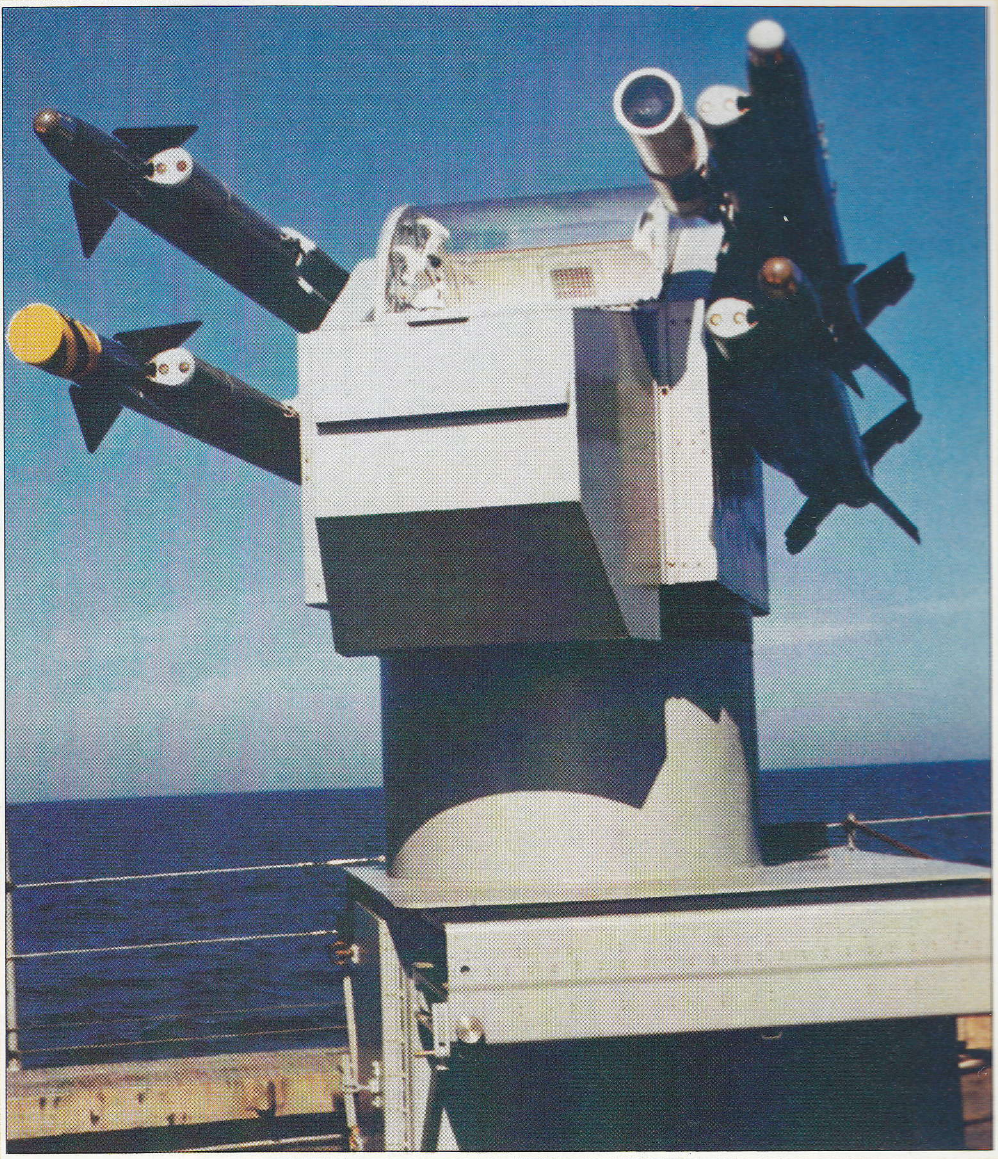
In the late 1950s the major perceived threat that the Soviets could field was a saturation attack by aircraft and missiles, in which the fleet's missile defences would have to cope with a large number of targets simultaneously. As the existing missiles such as Talos and Terrier were tactically limited by their requirement for target illumination by dedicated radar from launch to interception, a new missile known as the Typhon was ordered into development in both medium- and long-range forms. The missile was to use new aerodynamic and electronic technology to overcome the saturation threat, but it was cancelled as the necessary technology ultimately proved to be beyond the capabilities of the industries involved at the time. However, many of the ideas and concepts devised for the system surfaced later in the AEGIS programme. Before this latter system matured, however, replacements for the Terrier and Tartar were still needed, and this resulted in the development of the Standard missile family. The Standard SM-1MR was evolved to replace the Tartar and the Standard SM-1ER to replace the Terrier. Using common components, the Standard SM-1MR was ultimately developed into the Standard SM-2MR for use with the multiple-target anti-saturation AEGIS system. This uses the inbuilt facility of the AEGIS system fire-control computers to command any missile's autopilot system in flight to provide continuous course updates so that the missile can fly a highly efficient trajectory to the vicinity of the target, where the semi-active homing seeker takes over. The more energy-efficient flight trajectory considerably increases the range of the SM-2MR, to the point where it matches that of the earlier SM-1ER missile. At the same time as the AEGIS system was being developed an improvement programme for the SM-1ER was underway. This resulted in the SM-2ER missile, which entered operational service in 1980 with a higher velocity and improved engagement envelope to enable it to defeat high-performance targets. Interestingly, the SM-2ER cannot be used with the AEGIS system as its performance is outside that system's capabilities. A nuclear-armed version of both the SM-2MR and SM-2ER is under development to allow the missiles to engage nuclear-armed cruise missiles at long range.



A standard MR missile is launched from USS Ticonderoga, *the first of the AEGIS cruisers. AEGIS is a complete air defence system, with advanced detection and control equipment designed to handle saturation air and missile attacks on the carrier battle group.*

In the late 1950s interest was directed toward a point-defence missile system that could replace the existing 76-mm (3-in) and 40-mm air-defence guns. This was due to be the Sea Mauler derivative of a US Army programme but, because of delays, an evaluation of available systems to serve as an interim system resulted in the Sea Sparrow Basic Point Defense Missile System being chosen. The British Sea Cat missile was the nearest rival but the Sea Sparrow was finally chosen over it because it was considerably faster and had a higher single-shot kill probability. Subsequently Sea Mauler was cancelled and the Sea Sparrow grew into a complete family of derivatives with variants based on existing air-to-air missiles. Apart from the new derivatives, the system was also improved through the fitting of a new target acquisition system that was introduced into the fleet from 1973 onwards. A version of the US Army's Chaparral SAM system was also used for a time on a number of FRAM destroyers during the latter stages of the Vietnam War after the USS *Higbee* had been hit by a bomb from a MiG in April 1972, but the system known as Sea Chaparral and using AIM-9D Sidewinder IR-homing missiles was rapidly removed from each vessel when it returned to the United States. This programme was followed by what has eventually become known as the multi-national Rolling Airframe Missile (RAM) RIM-116A. This is a short-range lightweight missile designed to complement close-in weapon systems. Using an entirely passive guidance package to counter active radar-homing cruise missile targets, its service entry has been delayed until the mid-1980s.

A full list of US Navy SAMs that have entered service is given in the accompanying table to show the evolutionary nature of most of the programmes.



Right: Developed from the land-based Chaparral system and using a version of the AIM-9 Sidewinder missile, Sea Chaparral saw limited use toward the end of the Vietnam War. The mounting is an adaptation of the Army M48 or M54 systems, with the operator inside the central post.

US Naval Surface-to-Air Missiles

	Range
1. RIM-2 Terrier area-defence missile	
RIM-2A beam rider	18.5 km (11.5 miles)
RIM-2B re-engineered RIM-2A	18.5 km (11.5 miles)
RIM-2C new tail controls and motor propellant	27.75 km (17.24 miles)
RIM-2D some re-engineering plus SSM capability	37 km (23 miles)
RIM-2D(N) nuclear version of RIM-2D with 1-kiloton head	37 km (23 miles)
RIM-2E first continuous-wave semi-active radar-homing version	37 km (23 miles)
RIM-2F new sustainer and power supply	74 km (46 miles)
2. RIM-7 Sea Sparrow point-defence missile	
RIM-7E5 Sea Sparrow version of AIM-7E	22.2 km (13.8 miles)
RIM-7H Sea Sparrow version of AIM-7E	22.2 km (13.8 miles)
RIM-7H5 NATO folding-fin version of AIM-7H	22.2 km (13.8 miles)
RIM-7F Sea Sparrow version of AIM-7F	22.2 km (13.8 miles)
RIM-7M improved low-level version of AIM-7M	22.2 km (13.8 miles)
3. RIM-8 Talos long-range area-defence missile	
RIM-8A first tactical Talos	92.5 km (57.5 miles)
RIM-8B first tactical nuclear Talos (5-kiloton yield)	92.5 km (57.5 miles)
RIM-8C extended-range Talos	185 km (115 miles)
RIM-8D extended-range nuclear Talos	185 km (115 miles)
RIM-8F modified RIM-8D with first continuous-wave seeker	185 km (115 miles)
RIM-8E Unified Talos, interchangeable warheads	185 km (115 miles)
RIM-8G SSM capability added	185 km (115 miles)
RGM-8H special anti-radiation homing version for shore targets	222 km (138 miles)
RIM-8J much modified Unified Talos	241.4 km (150 miles)
4. RIM-24 Terrier medium-range area-defence missile	
RIM-24A semi-active homing with SSM capability	13.7 km (8.5 miles)
RIM-24B Improved Tartar	32.2 km (20 miles)
5. RIM-66 and RIM-67 Standard area-defence missile	
RIM-66A Standard SM-1MR with SSM capability	46.25 km (28.75 miles)
RIM-66B improved Standard SM-1MR	67.06 km (41.7 miles)
RIM-66C Standard SM-2MR for AEGIS	74 km (46 miles)
RIM-67A Standard SM-1ER	74 km (46 miles)
RIM-67B Standard SM-2ER	148 km (92 miles)
6. RIM-116 RAM point-defence missile	
RIM-116A Rolling Airframe Missile (RAM)	9.25 km (5.75 miles)
7. Sea Chaparral point-defence missile	
AIM-9D IR-guided Sidewinder	8.05 km (5 miles)

of the ship's normal missile outfit. Further improvements are underway to both missile types to counter high-level diving missile targets. The Standard SM-1MR is used by Australia, France, Italy, Japan, the Netherlands and USA, while the SM-1ER, SM-2MR and SM-2ER variants are reserved to the US Navy.

Specification
RIM-66A Standard SM-1MR
Type: medium-range area-defence missile
Dimensions: length 4.47 m (14 ft 8 in) diameter 0.343 m (1 ft 1.5 in); span 0.914 m (3 ft 0 in)
Weights: total round 578.8 kg (1,276 lb); warhead ? HE
Performance: maximum speed Mach 2+; range 46.25 km (28.75 miles); maximum altitude 15240 m (50,000 ft)

Specification
RIM-66B Standard SM-1MR
Type: medium-range area-defence missile
Dimensions: length 4.724 m (15 ft 6 in); diameter 0.343 m (1 ft 1.5 in); span 0.914 m (3 ft 0 in)
Weights: total round 608.7 kg (1,342 lb); warhead ? HE
Performance: maximum speed Mach 2+; range 67 km (41.6 miles); maximum altitude 19050 m (62,500 ft)

Specification
RIM-66C Standard SM-2MR
Type: medium-range area-defence missile
Dimensions: length 4.724 m (15 ft 6 in); diameter 0.343 m (1 ft1.5 in); span 0.914 m (3 ft 0 in)
Weights: total round 608.7 kg (1,342 lb); warhead ? HE
Performance: maximum speed: Mach 2+; range 74 km (46 miles); maximum altitude 24385 m (80,000 ft)

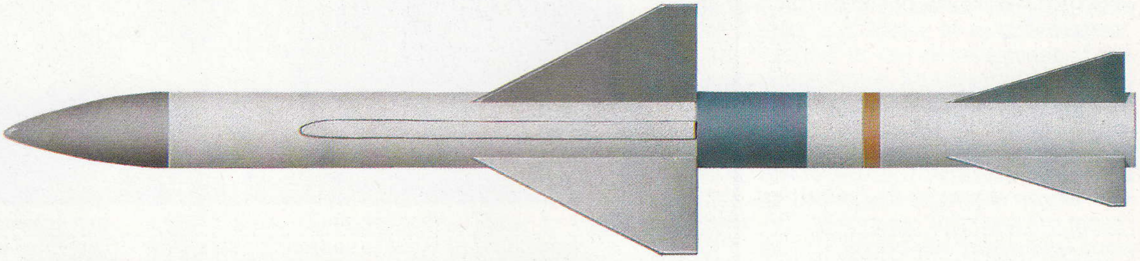
Specification
RIM-67A Standard SM-1ER
Type: medium-range area-defence missile
Dimensions: length 7.976 m (26 ft 2 in); diameter 0.343 m (1 ft1.5 in); span 0.914 m (3 ft 0 in)
Weights: total round 616.9 kg (1,360 lb); warhead ? HE
Performance: maximum speed Mach 2.5+; range 74 km (46 miles); maximum altitude 24385 m (80,000 ft)

Specification
RIM-67B Standard SM-2ER
Type: long-range area-defence missile
Dimensions: length 8.23 m (27 ft 0 in); diameter 0.343 m (1 ft 1.5 in); span 0.914 m (3 ft 0 in)
Weights: total round 1387.1 kg (3,058 lb); warhead ? HE
Performance: maximum speed Mach 2.5+; range 148 km (92 miles); maximum altitude 30480 m (100,000 ft)

Off San Juan, the 'Belknap' class cruiser USS* Wainwright *fires an SM-2ER missile. The extended range version of the Standard with the aid of the large booster motor is capable of ranges in the region of 150 km (93 miles), and the improved electronics and guidance enhance the performance considerably.

USA

Sea Sparrow



Based on the AIM-7 Sparrow family of air-to-air missiles, the RIM-7 Sea Sparrow provides basic point defence for the US and NATO navies.

In the early 1960s the Sparrow proved to be the best missile to form the basis of the **Basic Point Defense Missile System** (BPDMS) for the US Navy. The first missile used, the **RIM-7E5**, of what has now become a family of **Sea Sparrow** missiles, was derived from the AIM-7E Sparrow air-to-air missile. This was then reconfigured into the **RIM-7H** round and then the **RIM-7F** was used, based on the much improved AIM-7F. The semi-active radar-homing Sea Sparrow's performance was quite impressive as its engagement range was between 14.9 and 22.3 km (9.25 and 13.86 miles) depending upon the target's altitude, which could lie between 30 and 15240 m (100 and 50,000 ft). All versions were, however, considered deficient against low-flying cruise missiles which had by then become a major threat to US naval forces. In order to rectify this defect, low-altitude radar guidance and fusing capabilities were to be given to Block I RIM-7F missiles to enable them to hit targets below 15 m (50 ft), whilst Block II missiles were to get enhanced ECCM features. However, both fixes were dropped from the programme as the RIM-7F was superseded on the

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The only missile defence carried by US Navy attack carriers is the Basic Point Defence Missile System, using Sea Sparrow missiles. The system has been in operation for some time, as this picture of USS* John F. Kennedy *taken in the Mediterranean in 1969 demonstrates.

Launch Systems

One of the most dramatic sights in modern military weaponry is the launch of a naval missile from a warship at sea. The missile is not the whole story, however: without the launcher, reloading systems and magazines there would be no defence at all against determined onslaught from an enemy attacking in numbers.

The launch rate and reliability of its launcher system have an important impact on the efficiency of the surface-to-air missile system as a whole. Throughout the development of naval SAMs the weapons have continually integrated new and improved design features that were adopted to permit faster and more efficient launching. First-generation systems such as the Sea Slug Mk 1, the Terrier and the earlier Talos variants were far less reliable than the artillery systems that they were designed to replace, so much so that check-out and even overhaul and assembly facilities were required as part of the missile stowage and loading system together with (until quite recently) the means of jettisoning and replacing dud rounds already on the launcher. Surprisingly, this last feature had a considerable effect on the physical design of the launcher itself. The missiles themselves were mostly stowed in horizontal magazines in the first generation of purpose-built and converted missile ships, and were fired from twin-arm launchers.

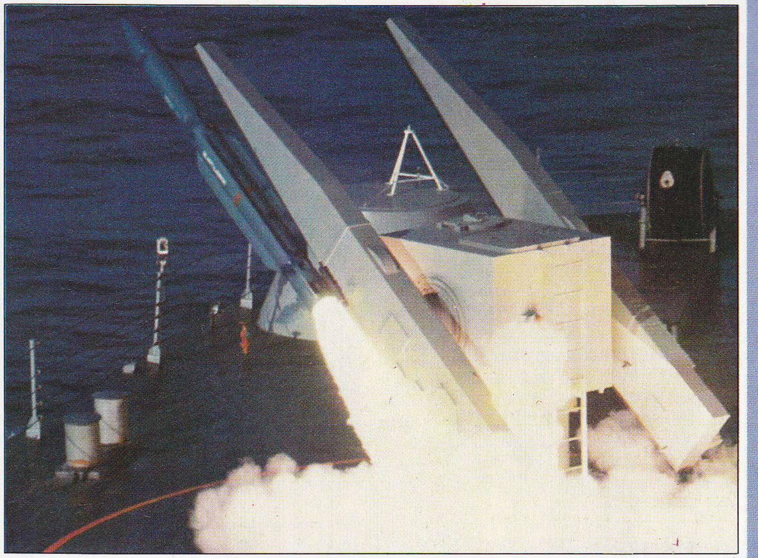
During the 1950s the concept of vertical stowage gained ground as it possessed the advantages of handling the missiles in attitudes much more suitable for the reduction of damage from shock, vibration or ship motion together with a reduction in the amount of handling equipment needed. The boosters and missiles could thus be mated in the magazine space and then placed on a ready-use ring below the launcher. However, because of its sheer size the Talos had to remain a horizontal stowage system.

The advent of the US Navy's Tartar for missile destroyers brought into service a highly automated vertical stowage system with both Mk 11 double- and Mk 13 and Mk 22 single-rail launchers.

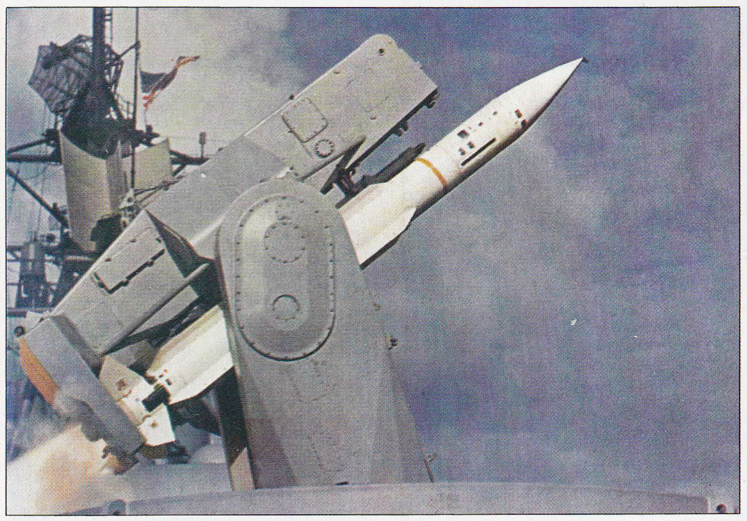
The latter type was devised to achieve a higher reliability than the twin-arm launcher whilst maintaining the same overall rate of fire. However, the adoption of the Tartar did have disadvantages: the missiles became more difficult to service (which ultimately precluded the use of a nuclear warhead for obvious safety reasons) and there was a lack of flexibility in accommodating other missile types (for instance, the modern 'Oliver Hazard Perry' class frigates with a Mk 13 launcher can carry only SAMs and the equivalent-sized Harpoon anti-ship missile but not the ASROC anti-submarine missile). The latter was one of the main reasons why the Mk 13 launcher was rejected for the AEGIS system, leading to the development of the new Mk 26 launcher. This has an even faster rate of fire and the ability to handle most type of missiles. This conventional twin rail launcher in turn is to be superseded by the Mk 41 vertical-launch system with individual compartments that can handle missiles up to and including the size of Tomahawk cruise missiles. The rate of fire is decreased to one round per second, though the capability of multiple-shot engagements is available far more readily than before.

The Royal Navy went to an automatic twin-rail launch system for the Sea Dart area-defence missile but stayed with hand loading for its new Sea Wolf point defence system, which has somewhat degraded the ability to cope with saturation attacks.

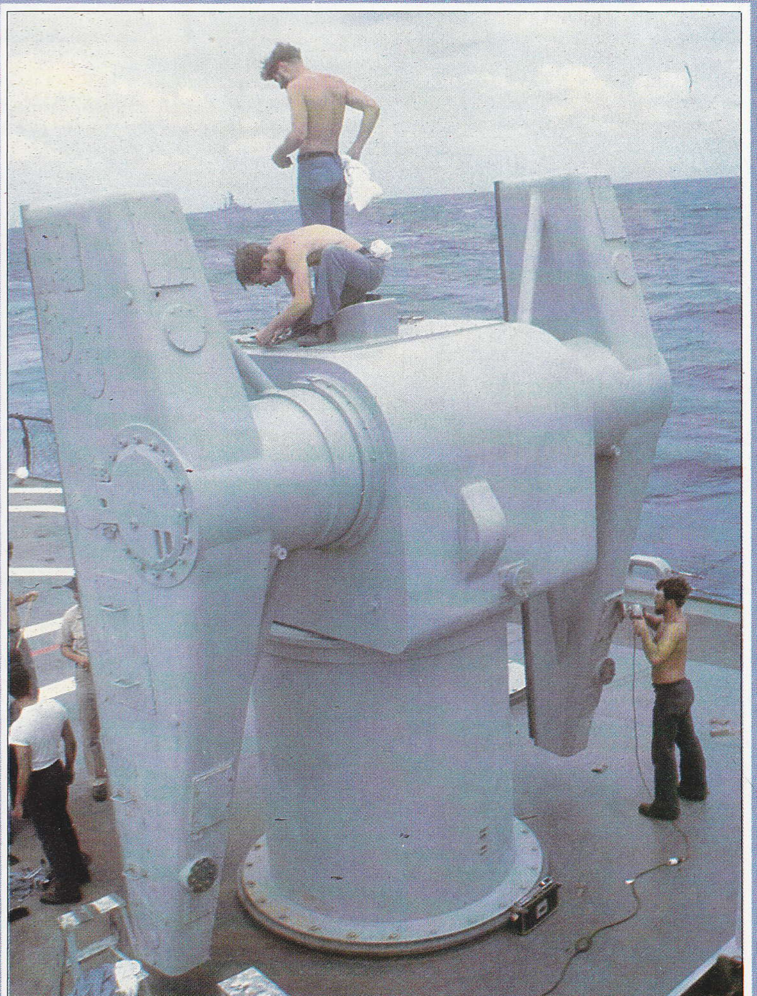
The Soviets more or less followed the US Navy in this pattern of development, but sprang the surprise of the first operational vertical-launch SAM launchers in the late 1970s with the SA-N-6 system; this uses rotary magazines to reload the individual launcher bins. A second missile system, of the point-defence type, is now entering service with the same rotary-reload launcher arrangements.



The GMLS Mk 26 is the fastest and most versatile launcher in US Navy service today. Fully automatic, the Mk 26 can handle Standard SAMs, Harpoon SSMs and ASROC ASW missiles, from magazines of 24, 44 or 64 round capacity. It equips the first AEGIS cruisers, but will be superseded by vertical launch systems.

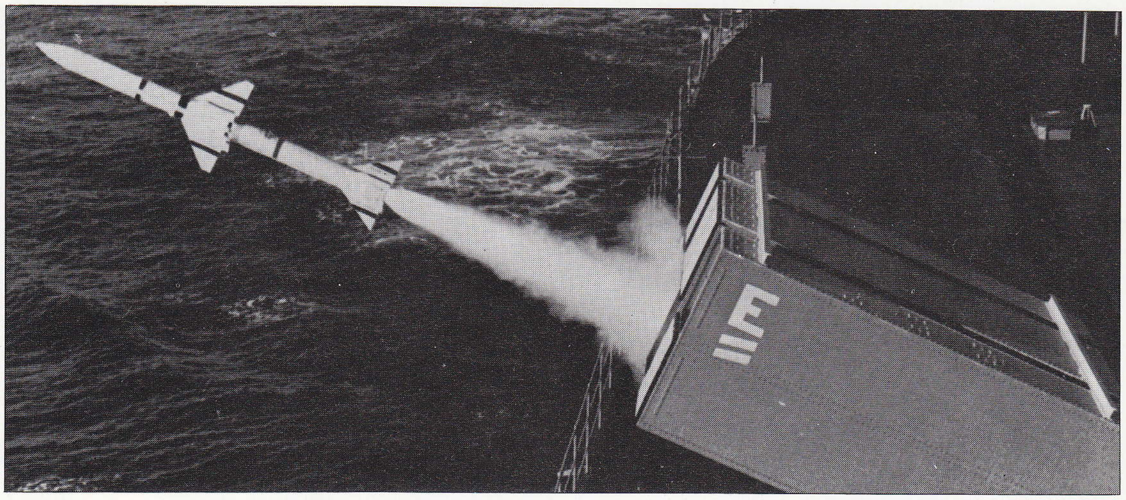


In between the Mks 10 and 26 twin-rail launchers, FMC produced the single-rail Mk 13 system. Fitted to missile destroyers as well as to the two nuclear cruisers California and South Carolina and to the 'Oliver Hazard Perry' class frigates, the Mk 13 can handle Terrier, Standard and Harpoon missiles.



The GMLS Mk 10 launcher is fitted to US Navy cruisers and larger destroyers as well as to cruisers of the Italian navy. Capable of firing Standard or Terrier missiles, the Mk 10 in its later models can also handle ASROC. The size of the system is indicated by the number of maintenance crew.

production line by the monopulse seeker-equipped **RIM-7M** version of the AIM-7M. This incorporates all the improvements from the start and in fact the US Navy is replacing all the previous Sea Sparrow variants in service by this missile as fast as it can. The **NATO Sea Sparrow** system differs from the BPDMS mainly in having fire-control systems that allow completely automatic engagements from target acquisition to missile impact. The missile used is the folding fin **RIM-7H5** version designed to fit the more compact eight-round launchers that NATO navies use. An **Improved PDMS** was introduced into the US Navy from 1973 onwards, and this has a much improved target-acquisition radar and data-handling system. The Sea Sparrow is operated by Belgium, Canada, Denmark, Greece, Italy, Japan, Norway, the Netherlands, Spain, the USA and West Germany.



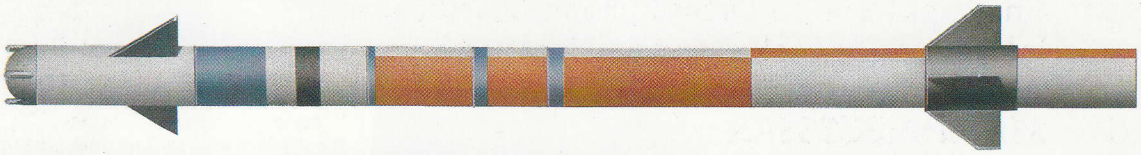
A Sea Sparrow missile is launched from its octuple box launcher aboard the amphibious command ship USS Mount Whitney.

Specification

RIM-7M Sea Sparrow
Type: point-defence missile
Dimensions: length 3.98 m (13 ft 1 in); diameter 0.203 m (8 in); span 1.02 m (3 ft 4 in)
Weights: total round 228.2 kg (503 lb); warhead 40-kg (88-lb) HE-fragmentation
Performance: maximum speed Mach 3+; range 22.2 km (13.8 miles); altitude limits 8-15240 m (25-50,000 ft)

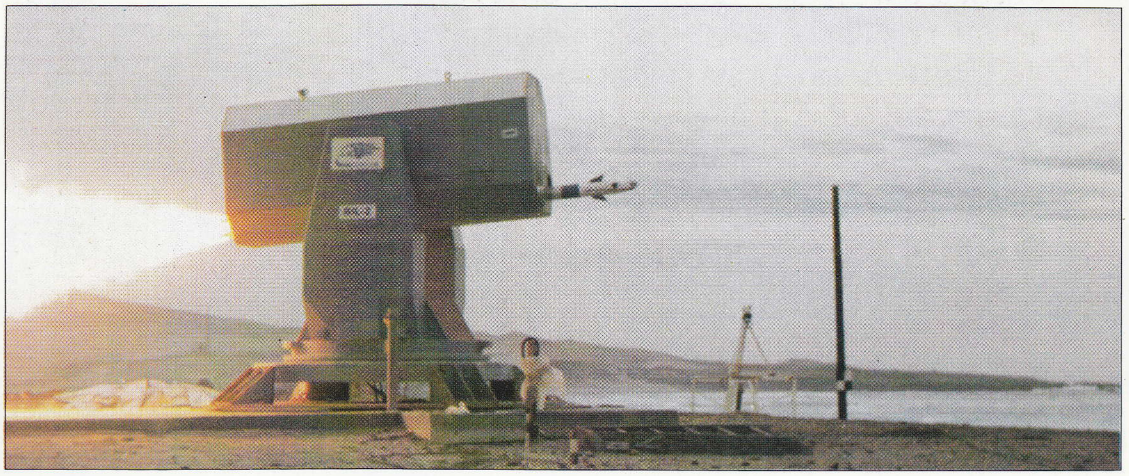
USA

RAM



The RAM, or Rolling Airframe Missile, employs components from both the Sidewinder AAM and the Stinger portable SAM, added to a passive radar seeker.

Interest in a short-range lightweight missile to complement the Phalanx close-in weapon system remained strong even after the Phalanx programme began in 1969. After considerable congressional pressure on the US Navy, the West German and Danish governments stepped in to save the programme from termination by signing memoranda of understanding to develop what by then was designated the **RIM-116A** or **Rolling Airframe Missile**, usually shortened as **RAM**, to arm both frigates and small combatants. The missile's unusual name is derived from the fact that it is spinning as it emerges from the launcher, after which fins are extended. Guidance is entirely passive, and initially uses a two-antenna broad-band radar seeker to point the terminal homing IR seeker head at the target. When this picks up the 'glint' of the target, the radar seeker is turned off as the IR guidance is considered much more accurate. The ship's fire-control system informs the missile's radar inferometer system of the frequency of the incoming target's active seeker head. The RAM employs the motor, fuse system and warhead of the Sidewinder air-to-air missile, the IR seeker of the Stinger surface-to-air missile, and the passive radar system described. The launcher will either be a newly developed 24-tube system on a Phalanx gun mount (for the two NATO navies) or a five-round unit inserted into each of two upper cells of an octuple Sea Sparrow/ASROC launcher on US Navy warships. Operational deployment of the system has been delayed until the mid-1980s although the trials have been successful.



This is the first test launch of RAM over water, with only the nose of the missile out of the launch box but with the front fins already deploying.

Well on its way, the RAM missile accelerates towards its maximum velocity of Mach 2. The system is designed to complement the Phalanx 20-mm gun in providing comprehensive close-in anti-missile defence.

Specification

RIM-116A RAM
Type: point-defence missile
Dimensions: length 2.794 m (9 ft 2 in); diameter 0.127 m (5 in); span 0.438 m (1 ft 5.25 in)
Weights: total round 72.1 kg (159 lb); warhead 10.2-kg (22.4-lb); HE-fragmentation
Performance: maximum speed Mach 2+; range 9.4 km (5.85 miles); altitude limits low to medium